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ELECTRONICS AND ELECTRICAL ENGINEERING

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USSR REPORT

ELECTRONICS AND ELECTRICAL ENGINEERING

25 September 1984

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USSR REPORT

ELECTRONICS AND ELECTRICAL ENGINEERING

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DOBERSHTEYN, S. A., KANEV, B. N. and ROZHDESTVENSKIY, A. N.

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[236-6900]

INVESTIGATION OF SURFACE ACOUSTIC WAVE FREQUENCY FILTERS WITH DIFFRACTION
GRATINGS

GRANKIN, I. M. and NELIN, Ye. A.

[Abstract] The selectivity of surface acoustic wave frequency filters em-
ploying acoustic analogs of optical diffraction gratings is investigated
theoretically and experimentally. The frequency response of the diffraction
grating is shown to be the Fourier transformation of the surface acoustic
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filter consisting of an input apodized transducer, a diffraction grating and
an output transducer is examined, showing the proposed selectivity enhancing
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[213-6900]

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VALEYEV, V. G.

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enhance suppression of signals from interfering targets. Moving-target
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Figures 2; references: 4 Russian.
[213-6900]

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SEREBRENNIKOV, V. I. and SHTEKHMAN, G. Ya.

[Abstract] The concept of a space-frequency ambiguity function of a phased
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and angular coordinates, is introduced. Range and azimuth resolution are
estimated with the help of Woodward's constant. Potential range and angular
coordinate measurement accuracy are analyzed. It is found that system
selectivity with respect to range and angular coordinate measurements alike
is degraded when wideband signals are used in radio systems incorporating
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degradation in range resolution and accuracy can be significant, and must
be taken into account even when the signal bandwidth is relatively narrow
when scanning a wide sector. The degradation in angular coordinate resolution
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[213-6900]

SYNTHESIS OF SYSTEMS FOR COHERENT WEIGHTED SIGNAL PROCESSING AGAINST
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POPOV, D. I. and KOSHELEV, V. I.

[Abstract] The problem of synthesizing processing systems is examined with
restrictions on the type of complex processing vector, which reduce the
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increased significantly by optimizing it simultaneously in combination with
a band rejection filter on the basis of a proposed iterative procedure which,
by optimizing the weight vectors of the filters and the optimal distribu-
tion of their orders, increases the effectiveness of the processing system.
Figures 2; references 8: 6 Russian, 2 Western.
[213-6900]

ANTENNAS AND PROPAGATION

MEASUREMENT OF EXTERNAL ANTENNA CHARACTERISTICS WITH ALLOWANCE FOR
DISTORTING FACTORS (REVIEW)

VOSKRESENSKIY, D. I., VORONIN, Ye. N., KOMAROV, V. M. and NECHAYEV, Ye. Ye.

[Abstract] Modern methods for improving measurement accuracy by making
allowance for the influence of the environmental situation under the
actual conditions in which antennas are operated and their parameters measured
are reviewed. The approach reviewed makes it possible to improve the
accuracy of antenna measurements without using technically complicated and
expensive means. Four scale and indirect methods of antenna measurements
which consider reflections from the ground are reviewed. Near-zone antenna
measurements made on especially shaped shielded test ranges are analyzed.
Time domain antenna measurements are described, and the use of space
wobbling to eliminate interfering factors is examined. Computational
methods for recovering directivity patterns with allowance for interfering
reflections are analyzed. Figures 14; references 83: 29 Russian, 54 Western.
[192-6900]

REMOTE SOUNDING OF FIELDS IN FEED RADIATORS OF MULTI-ELEMENT ANTENNA SYSTEM
WITH ALLOWANCE FOR INTERACTION WITH SOUNDING DEVICE

GUZEYEV, I. V. and DEMIDOV, V. V.

[Abstract] An antenna system incorporating an arbitrary type of distribu-
tion system and a multi-element antenna array is sounded in order to recover
the complex amplitudes of the incident waves on the inputs of the array
feeds from the responses (readings) of the amplitude and phase meter of

the sounding device measured in the near field of the array. The distribution of the complex amplitudes is recovered by means of a linear operator which takes into account the electrodynamic interaction of the probe and the antenna system. Amplitude-phase distribution recovery error caused by failure to account for interaction between the sounding system and the antenna system is modeled by computer. Analogous methods can be employed in order to investigate interaction affects in an antenna array – probe device system and to recover the amplitude-phase distribution of the currents and voltages at the inputs of the radiators. Figures 4; references: 6 Russian.
[192-6900]

ANALYSIS OF FLAT FINITE MULTIELEMENT ANTENNA CONSISTING OF WAVEGUIDE RADIATORS

KHZMALYAN, A. D.

[Abstract] An element-by-element spectral approach is used to construct an effective mathematical model of a finite multielement antenna consisting of rectangular waveguides. The antenna studied is formed by the apertures of rectangular waveguides arranged on a metal shield on the xy plane at the nodes of a two dimensional equidistant grid. An antenna consisting of 10 x 10 (95) radiators is analyzed as annexample. The method can be used to analyze antennas with a significant number of elements within a rigorous electrodynamic framework. Figures 2; tables 1; references 11: 9 Russian, 2 Western (1 in Russian translation).
[192-6900]

CHARACTERISTICS OF CIRCULAR-POLARIZED PRINTED RADIATORS IN PLANAR PHASED ANTENNA ARRAY

FILIPPOV, V. S. and SHATOKHIN, B. V.

[Abstract] The results of a numerical investigation of the characteristics of single-channel circular polarized printed radiators in a planar-phased antenna array with a rectangular periodic structure are presented. The relationship between the longitudinal and transverse plate dimensions and the phase shift between orthogonal components of the radiation field are

analyzed. The driving amplitude of each of the orthogonal components of the radiation field is found to depend upon the distance between the excitation point and the corresponding axis of symmetry of the plate; the distance from the center of the plate to the excitation point determines the input impedance of the radiator. The impedance and polarization characteristics of a printed radiator are analyzed as a function of frequency. The polarization characteristics of a feed in an array is found to be affected significantly more strongly by distortions than the impedance characteristics. Figures 3; tables 1; references 5: 3 Russian, 2 Western.
[192-6900]

GREEN FUNCTION METHOD IN THEORY OF MICROSTRIP ANTENNAS

PANCHENKO, B. A.

[Abstract] Use of the Green Function in order to simplify analytical algorithms and save time in computer aided design of miniature functional components of microstrip antennas employed as antenna feeds is examined. Representation of the Green function as an expansion with respect to TE and TM waves is discussed. The partial investigations of microstrip antennas indicate the versatility of the Green function method, which is especially useful for investigating three-dimensional integrated circuits containing channeling as well as radiating devices. Figures 2; references 9: 5 Russian, 4 Western (1 in Russian translation).
[192-6900]

INVESTIGATION OF CHARACTERISTICS OF PHASED ANTENNA ARRAY CONSIDERING INTERACTION BETWEEN RADIATORS AND PROPERTIES OF POWER DIVIDER

FILIPPOV, B. S. and PAVLOV, S. A.

[Abstract] A method is proposed for investigating the characteristics of infinite block phased arrays in which the elements form a regular structure, with allowance made for a power divider, which provides arbitrary amplitude-phase distribution within the block. The influence of nondissipative dividers, as well as dividers incorporating absorbing elements, is investigated. An effective algorithm is constructed for analyzing the characteristics of

block phased arrays designed for scanning within a limited angular sector,
and of ordinary phased arrays with element-by-element phasing, with
allowance for interaction of the radiators with respect to external space
as well as through the power circuits. The numerical results indicate that
the influence of the power divider must be taken into account when designing
phase antenna arrays. Figures 4; references 5: 4 Russian, 1 Western in
Russian translation.
[192-6900]

FAST METHOD FOR CALCULATING RADIATION PATTERNS OF NONEQUIDISTANT RADIATOR
SYSTEMS

DANILENKO, A. N. and KISHCHENKOV, M. O.

[Abstract] An FFT method is proposed which can be used directly to compute
the radiation patterns of nonequidistant systems of radiators, providing a
substantial savings in time over the traditional method. A computational
experiment used to estimate the speed with which radiation patterns are
computed by the proposed method is described. The method allows the FFT
approach to be used when the initial function is assigned by a nonequidistant
system of samples, e. g. in calculating the spectra of a nonequidistant pulse
sequence or interpolating a function assigned by a nonequidistant system of
samples. Figures 1; references: 2 Russian.
[192-6900]

SCATTERING MATRIX OF ANTENNA ARRAY WITH JOULE LOSSES IN RADIATORS

TOKARSKIY, P. L.

[Abstract] Expressions are derived for the elements of the scattering matrix
of an antenna array with an allowance made for radiator losses. The formulas
derived make it possible to use the scattering matrix to analyze and to
synthesize antenna arrays with the dissipative radiators. The amplitudes
of incident and reflected waves in the lines driving the input terminals of
a system of identically polarized radiators are analyzed as an example of the
use of the matrix. Figures 1; references: 3 Russian.
[192-6900]

SYSTEM OF EQUATIONS FOR FINDING ANTENNA RADIATION PATTERN FROM NEAR-FIELD SAMPLES

SOLOVTSOV, S. L.

[Abstract] A formula is derived which provides for the expansion of the electrical field with respect to the system of plane waves passing through a slit with width "a" in an opaque screen in a plane z = 0, which is valid for any antenna whose size does not exceed "a". The method is checked numerically for selected parameters. It is found that the error of the proposed method is smaller by an order of magnitude than the traditional method, and that it provides a wider reproduction sector. The weight coefficients differ significantly from the coefficients of the discreet Fourier transform, which have the same amplitude and linear phase creep. The norms of the coefficients in both cases are approximately the same. Figures 2; references: 3 Russian.
[192-6900]

CHARACTERISTICS OF TWO-FREQUENCY COMBINED DIPOLE ANTENNA ARRAYS

IL'INSKIY, A. S., PONOMAREV, L. I., BEREZHNAYA, I. V. and DOLGIY, A. V.

[Abstract] The mutual distortions in combined two-frequency dipole antenna arrays are analyzed as a function of the thickness and relative positioning of dipoles operating at different frequencies. An electrodynamic model of a two-frequency array incorporating a system of thin half-wave dipoles is employed. The amplitude patterns in different subbands are analyzed as a function of the dipole thickness. The results make it possible to represent more fully the distortions occurring in the characteristics of two-frequency combined arrays, as well as their relationship with the relative positioning and thickness of radiators operating at different frequencies which, in turn, makes it possible to assess the advisability and prospects for using combined dipole arrays in various radio systems. Figures 4; references: 1 Russian.
[192-6900]

MICROSTRIP ANTENNA FOR MULTICHANNEL RADIOMETER

KNYAZEV, S. T., NEFEDOV, Ye. I. and PANCHENKO, B. A.

[Abstract] A microstrip antenna designed for installation aboard
agricultural aircraft as part of a radiometric moisture meter operating in
the 2-, 18 and 30 bands is described, which provides minimum losses and has
no horizontal side lobes. The basic parameters of the experimental array
patterns at the center and boundary frequencies of the working bands are
given. The use of microstrip radiators makes it possible to implement a
moisture meter antenna system with superior operating and electrodynamic
characteristics. Figures 2; tables 1.
[192-6900]

ALGORITHM FOR TRACKING MANEUVERING OBJECT WITH AMBIGUOUS MEASUREMENTS

KOVAL'CHUK, I. A.

[Abstract] A quasi-optimum algorithm for the tracking of a maneuvering
object with ambiguity in the measurements is obtained. An adaptive estima-
tion method based on a group of Kalman filters operating in parallel and
producing conditional estimates is employed. A flowchart explaining the
operation of the algorithm is presented. The algorithm is tested by computer
and shows effective filtering of the range estimates and some inertia in the
velocity estimate as compared with target tracking, with no ambiguity in the
measurements. The algorithm can be used for trajectory tracking tasks and
for the more general problem of estimating the state of a stochastic discrete
system with ambiguous measurements. Figures 2; references 9: 5 Russian,
4 Western (1 in Russian translation).
[236-6900]

ENERGY PARAMETERS OF OPTICAL RADIATION SPACE RESEARCH SYSTEMS

RUMYANTSEV, K. Ye.

[Abstract] A method for spatial searching for optical radiation modulated
by the intensity of the subcarrier is extended to the analysis of search
systems employing direct photodetection, using a strip of matrix photo-
detectors in which the individual elements are sampled sequentially.
Formulas are derived which make it possible to compare search systems
employing dissector and matrix photodetectors. Figures 2; references 6:
5 Russian, 1 Western in Russian translation.
[236-6900]

PECULIARITIES OF MICROPROCESSOR IMPLEMENTATION OF ALGORITHMS FOR PROCESSING
RADIO SIGNALS AND NOISE IN LARGE ANTENNA ARRAYS

POPOVSKIY, V. V. and GLUSHANKOV, Ye. I.

[Abstract] A method for speeding up computational procedures by parallel-
ing the processing algorithms is examined. Two common types of processing
algorithms are analyzed: with direct inversion of the sampled covariation
matrix, and estimating the weight coefficient vector of the adaptive array
by the state variable method. The use of a distributed multiprocessor system
to speed up microprocessor operation is described, and the paralleling of the
algorithms developed by such a computer system is explained. Figures 2;
references: 8 Russian.
[236-6900]

EFFICIENCY OF INTEGRAL ACTIVE ANTENNAS

KONTOROVICH, M. I. and LYAPUNOVA, N. M.

[Abstract] It is demonstrated on the basis of previously published findings
of the authors that the presence of feedback in active receiving antennas

does not change the assumptions, and that the addition of an amplifier to
a miniature antenna does not improve its efficiency over that of active
antennas without feedback, but it does expand the dynamic range as long as
the feedback is negative. The operation of an equivalent "noise" active
antenna circuit is analyzed. It is found that the noise characteristics
of an active antenna rea not changed by the introduction of negative feedback.
Figures 2; references 4: 3 Russian, 1 Western.
[198-6900]

DISTORTIONS OF RADIO PULSES DURING REFLECTION FROM MAXIMUM REGION OF
IONOSPHERIC LAYER

NAMAZOV, S. A., ORLOV, Yu. I. (deceased) and FEDOROV, N. N.

[Abstract] The influence of dispersion distortions on the structure of
radio pulses reflected from the maximum region of the ionospheric layer,
as approximated by a symmetrical Einstein profile, are examined. The far-
zone condition for the reflected signal is obtained by using the concept
of Fresnel spaces, and formulas are derived for calculating the envelopes
of the reflected signals in the far-zone approximation. Different methods
are also examined for determining the group delay time for frequencies close
to the critical frequency of the layer in the presence of dispersion
distortions of the reflected radio pulses, where traditional methods for
finding the group delay cannot be used. A fast Fourier transform algorithm
is employed for the analysis, and the interpretation is based on the space-
time geometric theory of diffraction. Figures 6; references 10: 8 Russian,
2 Western (1 in Russian translation).
[213-6900]

CHARACTERISTICS OF POLARIZATION GRIDS MADE OF PARALLEL METAL STRIPS DURING
HEMISPHERICAL SCANNING

RUD', L. A.

[Abstract] The behavior of the polarization and energy characteristics of
waveguide-type blade grids during hemispherical scanning are examined.

Near-optimal constructions are defined, and basic factors influencing the performance of the devices are established. Figures 2; references 9: 7 Russian, 2 Western.
[213-6900]

DISTRIBUTION OF ATMOSPHERIC RADIO INTERFERENCE

DOBRYAK, D. S.

[Abstract] The statistical description of atmospheric radio interference as a random process is investigated. A statistical model for atmospheric interference is sought which has the minimum possible number of model parameters. The instantaneous values of atmospheric interference are found to represent the random (Poisson) sum of normal random quantities. The field intensity of atmospheric interference is found to represent a non-gaussian random process which is fully defined by two generalized parameters: the rate of occurrence of the pulses forming it (atmospheric) and the autocovariation function of that process. The hypothesis that the instantaneous values of atmospheric noise are described by a unidimensional distribution was tested by recording the vertical electrical component of the natural electromagnetic field in the 0.1 25 kiloKHz band experimentally. As a random process, atmospheric interference is found to be fully described by its spectral density and by the intensity of the atmospherics. The author thanks B. A. Khadzhi for participation in a discussion of the results stated in the work. Figures 3; references 14: 12 Russian, 2 Western. [213-6900]

ASYMPTOTICALLY OPTIMAL RANKING ALGORITHMS FOR QUASI-DETERMINATE SIGNAL DETECTION

BRIKKER, A. M.

[Abstract] The structure of an asymptotically optimal ranking algorithm for quasi-determinate signal detection is synthesized, in which the signal has a constant component, the distribution density of the interference is of a known type, and the constant component and intensity of fluctuations of the interference are unknown. Conditions necessary for achieving optimality are defined and analytical expressions for the detection

characteristic are obtained. The asymptotic effectiveness of ranking algorithms is established for cases in which the actual received signal and interference density differ from the expected models. The findings relate to quasi-determinate signals represented as expansions with respect to an orthonormal system of functions with random parameters uniformly distributed on a hypersphere. Examples of asymptotically optimal ranking algorithms are presented. The structural diagram of a detector which implements one of the algorithms is shown. Figures 2; references 8: 5 Russian, 3 Western (2 in Russian translation).
[213-6900]

ANALYSIS OF SPIN ECHO SIGNALS IN MULTI-PULSE EXPERIMENT

DUDKIN, V. I., PETRUN'KIN, V. Yu. and TARKHANOV, V. I.

[Abstract] A method is examined for determining the connection between the parameters of any echo signal and the parameters of the perturbing radio pulses for a paramagnetic substance located in an external heterogeneous magnetic field, disregarding relaxation processes and the form of the magnetic resonance line. Echo signals are classified in the language of Kelly-Klein parameters by using a modified Jensen pattern. The effect of two LFM radio pulses with specified parameters applied to a spin system is analyzed as an example. It is found that different spins contribute to the initial echo signal at different moments, and that there is an additional shift in the echo signal which depends upon the ratio of the amplitudes of the perturbing pulses. The method can be extended to any multi-pulse sequences and can be used to examine more complex cases in which allowance for the form of the magnetic resonance line, the relaxation processes and the characteristics of the formation of nuclear spin echo signals in poly-crystalline magnetically ordered substances. Figures 2; tables 1; references 16: 8 Russian, 8 Western (2 in Russian translation).
[213-6900]

EXPERIMENTAL DETERMINATION OF PROPAGATION RATE OF ELF SIGNALS EMPLOYED BY
OMEGA RADIO NAVIGATION SYSTEM FOR PHASE MEASUREMENTS

KOTYASHKIN, S. I.

[Abstract] Determination of the phase velocity along the propagation path
of an ELF signal by taking measurements at a single point is discussed.
Accurate single-point phase veloctiy determinations require single-mode
propagation of the ELF signal at the receiving point, very small arguments
of the excitation coefficients for the two transmitters, a sufficiently long
interval of unambiguous measurement results and geodetic-line propagation of
the signal over long paths. Experimental measurements of the signals from
the Omega radio navigation system at 10.2 KHz during 12-18 May 1981 are
described. The data obtained can be used to estimate variations in the
effective altitude of the ionosphere during heavy solar activity, and for
calibrating the Omega radio navigation system by refining the theoretical
phase velocities. The author thanks A. D. Levents for assistance in
organization and conducting the experiment. Figures 2; tables 1;
references 6: 2 Russian, 4 Western.
[213-6900]

NEW SYNCHRONOUS 'KINOR 35S' TRIPOD MOUNTED OR SHOULDER HELD MOTION PICTURE CAMERA

SOLOMATIN, S. A. and BYCHKO, Ye. G., Moscow Design Office for Motion Picture Equipment

[Abstract] The "Kinor-35S" represents a new generation of motion picture equipment designed by the Moscow Motion Picture Equipment Design Office. It is a 35 mm camera for making motion pictures in color or black and white from either a tripod mount or when shoulder held, with simultaneous synchronous high fidelity recording of the audio. The camera weighs 15 kg, operates in an ambient temperature range of -30 to +40 °C, has a picture jitter of no more than 0.1 mm and curve A noise level of 28 ± 1 dB. It is powered from a Nicad battery at 16 V with a capacity of 8 or 3 A·hr, or AC mains at 220 volts with a separate power supply. The film transport mechanism is designed entirely around toothed belt drives and is discussed in some detail. The camera control unit provides for crystal controlled frame speeds of 24 and 25 frames/sec, as well as a continuously variable speed of from 8 to 32 frames/sec. A major advantage of this new generation design is the synchronous sound recording feature. The first industrial production series of these cameras will come off the line in 1984 at the "Moskinap" plant. The "Kinor-35S" is protected by USSR Patent Nos. 185509, 559208 and industrial prototype certificate No. 14923. Figures 3.
[147-8225]

KEP-15 EQUIPMENT SET FOR CAMERA LENS AND SHUTTER CONTROL

GRINENKO, E. N. and KUZNETSOV, Yu. M., Central Design Office for Motion Picture Equipment of the Ekran" Scientific Production Association

[Abstract] The Central Design Office for Motion Picture Equipment of the "Ekran" Scientific Production Association has developed a new set of control units in the KEP-15 series to replace the obsolete KEP-5 equipment for the control of camera lens systems: KEP-15.00 and KEP-15.000-01 for controlling the focal distance of the 350PF series of objective lenses with focal distance scale rotation moments of no more than 0.2 and 0.4 N·m, respectively; KEP-15.000-02 for controlling the stop setting; and the KEP-15.000-03 for controlling the focusing range. This set of control devices makes it possible to change the focal distance of an objective continuously at a variable rate, to preset the range of variation in the focal distance and to generate focal distance and stop settings using remote control. The entire set of five components weighs no more than 1.15 kg, and is powered at a nominal supply voltage of 15 +3, -1.5 volts. The time required for changing the focal distance from the maximum to the minimum can be varied from 5 to 180 seconds. The minimum time for changing the distance and stop settings is no more than 1.5 seconds and the precision in generating angular positions is within $\pm 0.5°$ for distance settings, and $\pm 1°$ for stop and focus settings (when controlled from the panel). The noise level at a distance of 0.75 m from the servo drive ranges between 32 and 38 dB maximum. A schematic of the IC and transistorized circuitry is shown along with an overall photo of the KEP-15 set. Figures 2.
[147-8225]

DEVELOPMENTAL TRENDS AND METHODS OF IMPROVING TELEVISION FILM SCANNERS

LUNEVA, Z. P.

[Abstract] The state of the art in telecine system design is discussed in the light of equipment development outside the USSR. Such systems include: Scanners designed around charge storage tubes (produced by RCA, Bosch-Fernseh, Philips, Cohu, Hitachi, etc.); systems using TV camera tubes with "diode" electron guns; a vidicon based telecine (TK-29 by RCA); an 8 mm motion picture film scanner developed by Thomson-CSF (France); flying spot scanners, used only in Europe; the Mark III telecine flying spot system with a frame memory (designed by Rank Cintel in England) for 35, 16 and 8 mm films and diapositives; systems based on single line CCD scanners; the FDL-60 telecine by Bosch-Fernseh (FRG) using these single line CCD transducers

with 1,024 elements, and a digital motion picture film transport system, color equalization, aperture correction and automatic illumination control. The B3410 CCD scanner developed by the Marconi Company is discussed in some detail, showing the configuration of the video channel with its CCD sensors and digital video signal processing with a frame memory, as well as the inter-lace scanning system. This general review notes that the use of frame memories, digital processing and control techniques, various types of equalizers and automatic controls as well as more sophisticated camera tubes, kinescopes and the single line CCD systems make it possible to develop telecine hardware which meets modern TV standards. Figures 5; references 14: 6 Russian, 8 Western (2 in Russian translation). [147-8225]

SELECTION OF PRE- AND POST-FILTERS FOR THE 4:2:2 DIGITAL TV STANDARD

KHLEBORODOV, V. A. and SHTEYNBERG, A. L.

[Abstract] The 4:2:2 digital TV standard calls for digitization of the Y brightness signal and two chrominance difference signals C_R and C_B at frequencies of 13.5 and 6.75 MHz respectively. The parameters of the pre-filters inserted at the A/D converter input for the Y_B, C_R and C_B signal conversion influence the quality of the resulting pictures, as does the amplitude-frequency response of the postfilters at the output of the D/A converter for the brightness and chrominance difference channels. This paper summarizes the findings of experimental studies of the impact of filter parameters on image quality. Implementation of digital TV requires that MKKR (International Radio Consultive Committee) recommendation 601 be supplemented with new specifications, including the parameters for the frequency response of these pre- and post-filters for the 4:2:2 standard. Considering the trend towards a constant increase of the resolution of TV equipment, it is expedient to adopt the 0.5T transition as the input signal model (T = 100 nsec). The pre- and post-filters for the brightness and color difference channels should has a frequency response which is flat with-in 0.1 dB with bandwidths up to 5.75 and 2.75 MHz, respectively; the attenuation at half the digitization frequency must be no less than 20 dB. The stopband attenuation should be no less than 40 dB for the pre-filter and no less than 26 dB for the post-filter (taking into account the filter-ing properties of the D/A converter). The degradation of the final image in mixed digital and analog TV channels can only be minimized by careful optimization of the parameters of these filters. Figures 3; references 10: 2 Russian, 8 Western. [147-8225]

NEW LIGHTING EQUIPMENT IN MOSFIL'M MOTION PICTURE STUDIO

KHAZANOV, G. I., "Mosfil'm" Motion Picture Studios

[Abstract] The All-Union Scientific-Research Institute for Motion
Pictures and Photography, the Kiev branch of the Odessa Design Office as
well as the Kiev "Kinap" plant, in conjunction with the "Mosfil'm" motion
picture studios, have done considerable work on the development, manufacture
and introduction of new motion picture lights with quartz-halogen lamps.
These lamps include the "Svet-2000M" and "Svet-5000" used for background
lighting; the "Kvartz-8000" shadeless light source; and the "Kososvet-5000"
light for uniform illumination of large areas. The "Zarya" light series
has also been modernized by using quartz-halogen lamps. Utilization of the
new and modernized lights in place of arc lamp projectors has enabled a
reduction in the installed capacity of the lighting and the electric power
consumption which amounts to 30% and 40%, respectively, below the present
norms. The "Vatra" production association of the USSR Ministry of the
Electrical Equipment Industry is manufacturing metal-halogen lamps for TV
service, including the "Lyuks-575" and "Raduga-2" lights, which have maximum
light intensities of 25 and 900 Kcd, respectively. The problem of strobo-
scopic effects caused by the fast response of metal-halogen lamps when
powered from the 50 Hz AC mains can be circumvented by various means, al-
though these are difficult and the studios are waiting for a new portable
AC generator with a capacity of 30 to 40 KW designed expressly for filming
purposes. Figures 10; references: 3 Russian.
[147-8225]

MOBILE TELEVISION NEWS REPORTING AUDIO MIXER AND SWITCHER

GOSTEYEVA, L. M. and TVERDOKHLEB, M. K., Kirovograd Radio Products Plant

[Abstract] The P-06 audio mixer panel, designed for operation with mobile
TV studios, was developed at the Kirovograd Radio Products Plant. The
mixer provides for the connection of 1 reporter's headset, an external
dynamic microphone and 2 telephone lines. The panel also has 3 outgoing
program channels, 1 telephone line and 2 talkback channels as well as a
switched outgoing standby audio feed channel. The output load impedance
is 600 ohms nominal, with a minimum value of 200 ohms; the nominal output
signal level is 1.5 ± 0.2 V; the nominal microphone input level is 1 ± 0.1
mV; the frequency response is flat within 1% between 30 and 15,000 Hz and
the harmonic distortion of the program outputs is no more than 2%. A
block diagram of the mixer is provided. Figures 2.
[147-8225]

PROSPECTS FOR DEVELOPMENT OF RADIO COMMUNICATIONS AND TELEVISION

VARBANSKIY, A. M., chief, Main Administration of Space and Radio
Communications, USSR Ministry of Communications

[Abstract] General directions in the development of radio communications
and television are outlined. Improvement of the network of TV distribution
and transmitting means, including expansion of the Orbita, Ekran and Moskva
TV satellite systems, is discussed. The need for improvement of existing
television transmitting equipment is noted. Work on stereo TV audio broad-
casting not requiring an additional audio channel is described. Work being
done to increase the number of radio broadcast programs and to improve
hearability is discussed. The development of a new digital radio broadcast
system in which a single transmitter can handle several different radio
broadcast programs is explained. Reduction of power consumption of trans-
mitting equipment by using biharmonic operation in the long- and medium-
wave bands is described. The expansion of radio telegraph service and of
satellite communications is touched upon briefly.
[215-6900]

METHODS FOR CONSERVING ELECTRICITY AT RADIO BROADCAST AND RADIO-TV
TRANSMITTING STATIONS

PUSTOVOYTOVSKIY, A. S., chief engineer, Republic Radio Broadcast, Radio
Communications and Television Center, Belorussian SSR Ministry of
Communications

[Abstract] Means for conserving energy by improving the energy indicators
of radio broadcast and television stations are outlined. The three basic
areas for improvement of transmitter power indicators are: 1) Improvement
of the electronic efficiency of HF amplifiers and modulators by employing
more economical modes; 2) Use of powerful oscillator tubes with improved
current distribution in order to increase the power gain of amplifiers and
thus to reduce the number of stages per circuit; and 3) Use of improved
amplitude modulation schemes (preferably with low-power control). Annual
savings at one station amounted to 300,000 kilowatt hours. There are
plans to install consumption meters on each transmitter belonging to the
Republic Radio Broadcast, Radio Communications and Television Center.
Figures 3; tables 1.
[241-6900]

19

SECOND PHASE OF INTEGRATED MODERNIZATION OF TRSA LOWER-POWER TELEVISION RELAYS

FRIDMAN, E. M., chief, Central laboratory of All-Union Radio-Television Transmitting Station (ORPS), SHELEPEN', I. V., chief specialist, and KOROTYCHEV, V. N., senior engineer

[Abstract] The second phase of the integrated modernization of type TRSA low-power television relays entails partial transistorization of the RF video and audio circuits and updating the final stage of the video transmitters. Structural and schematic diagrams of the modernized TRSA audio and video circuits are presented. The process of switching television relays over to unattended operation requires gradual transistorization of equipment and the replacement of existing hardware. The technical treatment presented repre-sents an intermediate stage on the way to complete transistorization of the existing pool of TRSA and RTSTA-70 TV repeaters. Figures 4.
[241-6900]

THRESHOLD DEVICE MODULE FOR K-24, K-60, K-60P AND K-1920 TRANSMISSION SYSTEMS

BLINOV, E. M., chief, TTs [Television Center] UMS-21, and KOLOKOLKIN, S. M., chief, Production Laboratory

[Abstract] The BPU-4 special device module for continuous monitoring of the pilot signal level in K-24, K-60, K-60P and K-1920 transmission systems is described. This module tracks the condition of the line circuit by follow-ing the level of the pilot signal, assessing the actual voltage at the out-put of the detector of the pilot signal receiver and outputting a 'normal', 'malfunction' or 'emergency' binary signal over two physical lines. The technical specifications of the module are enumerated. During 1979-1983, 4,500 of these modules were put into operation. A test of the short-term stability of the thresholds of 200 of these, which have operated with K-60P equipment for 3 years, demonstrated that the modules have good operating reliability and stable basic parameters. Figures 1; tables 2.
[241-6900]

USE OF TRANSISTOR AMPLIFIERS IN PORTABLE AUDIO AMPLIFIER STATIONS

ZORIN, I. F., chief engineer, Moscow City Radio Translation Network Public Address System and Technical Installation Center, and GUTAROV, V. K., senior engineer, Radio and TV Technical Service Center

[Abstract] A description is given of a 1-Kilowatt AUC and the more powerful ADS-2250 transistor amplifier racks developed by the Moscow City Radio Translation Network in conjunction with Czechoslovakian colleagues at the Tesla-Vrable plant for the purpose of re-equipping and standardizing transportable audio amplifier stations. The devices combine the power from ten identical 100-watt AUI-636 amplifier modules for the AUC-2101, or five 500-watt ADI-636 amplifier modules for the ADS-2250. Parallel combination of the power from individual modules makes it possible to implement an economical emergency backup system, because only the malfunctioning module disconnects in case of a malfunction, rather than the entire amplifier rack. The amplifiers have efficient temperature stabilization circuits and short circuit/overload protection. The modules comprising the AUC and ADS racks are self-contained and are small and light in weight. Portable operation of AUI-636 and ADI-636 amplifiers, as well as AUC-2101 and ADS-2250 amplifier racks, have demonstrated good reliability, economy and dimensions.
Figures 5; tables 1.
[241-6900]

SIMPLICITY OF DECISION FUNCTIONS IN PROBLEM OF ADAPTIVE PATTERN RECOGNITION

VASIL'YEV, V. I., Scientific and Technical Committee, Institute of Cybernetics imeni V. M. Glushkov, UkSSR Academy of Sciences, Kiev

[Abstract] The concept of simplicity is applied to the mechanism of adaptive pattern recognition. Simple rules are established, itself a difficult problem most expediently treated with graphs, whereupon a simple problem of pattern recognition is defined as one solvable by a linear rule in a space of low dimensionality. On this basis and according to theorems in the theory of probability, the extrapolational properties of adaptation are determined. The performance of the adaptation process is evaluated in terms of the outcome, namely quality and specifically error of the result. Increasing the reliability is treated first from the standpoint of prolonging the adaptation process and thus increasing the sample size, then from the standpoint of simplicity as guarantor of reliability. Figures 2; tables 3; references 8: 7 Russian, 1 Western (in Russian translation). [208-2415]

MINIMAX CLASSIFICATION OF PATTERNS WITH RANDOM INDEPENDENT PARAMETERS

DUNAYEV, B. B., Kiev

[Abstract] Minimax classification increment functions are determined for patterns with random independent parameters, the object being to minimize the recognition error. Both the Bayes mean risk and the minimax mean risk are calculated by the Lagrange method, the resulting system of equations being solvable by numerical methods. The dependence of each mean risk on the normalized mean-square error of parameter reading according to a given

classification reveals that minimax classification will reduce the mean risk of recognition error when the reading error is $z \geq z_M$ for $i = 1,2,...,N$ parameters and $j = 1,2,...,M$ classes or nonintersecting regions (n-dimensional M-hedral hypersurfaces separating them). In a typical example $z_M \approx 0.67$ for $N = 15$ and $M = 4$. Figures 1; references: 2 Russian. [208-2415]

DETERMINATION OF UNOCCUPIED CHANNEL NOISE INDUCED IN BUILT-UP CHANNEL BY DIGITAL SYSTEMS WITH PULSE-CODE MODULATION

DAVYDOV, Yu. G. and KORDONSKIY, E. V.

[Abstract] The noise power at the output of an unoccupied voice-grade channel formed by a digital pulse-code modulation transmission system is found to depend upon the input noise power and the position of the operating point of the coder. The noise power is independent of the position of the operating point of the coder for unweighted input noise values over -64dBmO but are determined by the input unweighted noise value. When voice grade channels with PCM equivalent are tandemed, each such tandem increases unoccupied channel noise by 83.3 pWO. Figures 3; references 4: 3 Russian, 1 Western. [212-6900]

SHOT NOISE COMPENSATION IN FM SIGNAL SYNTHESIZERS EMPLOYING FRACTIONAL DIVIDER WITH VARIABLE DIVISION FACTOR

KOCHEMASOV, V. N.

[Abstract] Measures are identified which help to improve the spectral characteristics of FM signals generated by synthesizers employing variable fractional dividers. A device is examined which generates linear frequency-modulated signals whose initial frequency and rate of frequency variation can assume discrete values. The synthesizer incorporates a variable oscillator, a pulse-phse detector, a synchronizer, a control unit, a digital-analog converter, a modulator, two adders and a filter. Analysis of the device indicates that the compensation accuracy depends upon the linearity and stability of the characteristics of the pulse-phase detector. Alternate ways of compensating for shot noise ahead of the pulse-phase detector are suggested. Figures 2; references 8: 4 Russian, 4 Western (1 in Russian translation). [212-6900]

PATH ACTIVATION IN LOGIC DEVICES

MOLCHANOV, A. A., REZNIKOV, I. F. and REZNIKOVA, I. A.

[Abstract] Formal existence conditions for activated paths for a set of
nodes in the circuit of a digital device are presented which can be used
in developing test synthesis algorithms. The types of connections between
two arbitrary nodes are defined formally, and a necessary and sufficient
condition for the existence of an activated path through a set of nodes is
formulated. It is demonstrated that the test construction problem can be
reduced to a problem of generating activated paths. An example of a cir-
cuit implemented by three modules is presented to illustrate the use of
the model. Combination of activated paths for individual modules to con-
struct the activated path for the entire circuit is demonstrated. The
algorithm can also be used to construct tests for serial circuits.
Figures 2; references 2: 1 Russian, 1 Western.
[236-6900]

REGULAR BINARY SEQUENCES WITH LOW SIDE LOBE SUPPRESSION LOSSES

IPATOV, V. P. and FEDOROV, B. V.

[Abstract] New fully regular coding rules are proposed on the basis of
synthesizing signals with low side lobe suppression filter losses by
mapping q-ary M-sequences onto a binary alphabet which generates families
of binary sequences with arbitrary small losses in the side lobe suppression
filter. Binary sequences constructed by using an Hadamard difference set
are examined. Numerous new binary sequences with low side lobe suppression
filter losses are derived with the help of the coding rule. The families
of sequences which are found include sequences which may be interesting from
the view point of nonperiodic (pulse) correlation properties. Tables 1;
references 8: 7 Russian, 1 Western in Russian translation.
[236-6900]

PARAMETRIC APPROACH TO LINEARIZATION OF MODELS OF SEMICONDUCTOR DIODE MIXERS

BAYUKOVA, Ye. V. and SHCHERBA, A. M.

[Abstract] The solution of differential equations describing an equivalent mixer circuit obtained by linearization on the basis of the parametric approach is examined. The spectral distribution of the amplitudes of the combination components of the voltage is investigated. The analysis of equivalent circuits of mixers with selective loading is examined. It is found that the parametric approach to linearizing models of semiconductor diode mixers often makes it possible to obtain a satisfactory form for writing the spectral distribution of the amplitudes of the combination components. The findings can be used when the final results must be represented as the superposition of harmonics or combination components. Figures 1; references: 4 Russian.
[236-6900]

SUBTRACTER WITH NUMBER-PULSE REPRESENTATION OF FREQUENCY DIFFERENCES

MALAKHOV, V. P. and NIKOLAYEV, Yu. A.

[Abstract] A frequency subtracter is developed which represents the frequency difference in a number-pulse code in which the problems are resolved of overcoming restrictions on the ratio of the input frequencies and preventing malfunctions when the pulses at the two converted frequencies coincide. The device simplifies subsequent circuits in digital devices. The circuit can be employed in numerous digital devices, including digital frequency filters and devices for determining the stretching or shrinking of tape materials and digital temperature measuring and regulating systems. Figures 2; references: 3 Russian.
[236-6900]

DIGITAL FREQUENCY MIXER FOR TWO-LOOP PHASE AUTOMATIC FREQUENCY CONTROL

SIMAKOV, V. A., KIZEYEV, A. A. and SEMENKO, A. I.

[Abstract] The development of a digital mixer to make it possible to use
digital integrated circuits to build frequency synthesizers is discussed.
Digital mixers employing EXCLUSIVE OR gates to extract the upper and lower
sidebands are described. Investigation of mixers based on series 133 in-
tegrated circuits indicate a 6 MHz upper frequency band for the device,
which can be increased by a factor of 2.5 by using a 530 series integrated
circuit. Figures 2; references 4: 1 Russian, 3 Western in Russian
translation.
[236-6900]

MATHEMATICAL MODEL OF ELECTRONIC CIRCUITS FOR FREQUENCY-DOMAIN OPTIMIZATION

ANISIMOV, V. I. and KOZ'MIN, N. G.

[Abstract] A mathematical model for time domain optimization is examined,
which allows for repeated computation of circuit functions and their
sensitivity to the variation of the optimized parameters and of the number
of parameters. The initial mathematical model is based on a system of
equations describing an equivalent 2-port whose inputs are the connection
nodes of the input (output) signals and circuit elements with varying
parameters. This system of equations is a generalized form of alpha-
numeric representation of the set of circuit functions, and makes it
possible to compute simultaneously numerous versions of a set of circuit
functions and their parametric sensitivity. References: 3 Russian.
[236-6900]

ALGORITHM FOR PARTITIONING CIRCUITS INTO PARTS

YEROKHIN, V. V. and NOSKOV, Yu. M.

[Abstract] A precise circuit partitioning method is proposed which employs
the minimum number of circuits connecting the different parts as a criterion.
The mathematical model of the circuit is a graph which overcomes the problems
in graph and hypergraph models for which optimal partitioning is difficult
or impossible. The algorithm is tested on a YeS-1033 computer for partition-
ing a circuit containing up to one thousand elements and as many subcircuits
into ten parts, requiring 150K RAM and 2.5 hours of machine time. The
algorithm is precise in the sense that it finds the optimum solution.
References 3: 2 Russian, 1 Western in Russian translation.
[236-6900]

SYNTHESIS OF WIDEBAND OSCILLATING SYSTEMS

ZAKHAROV, A. V.

[Abstract] A method is described for increasing the bandwidth of adjustable
losless systems based on the theory of electrical circuit sensitivity. A
method for mutual compensation of the zeros and poles of the reactance is
described. The extension of the method to oscillating systems representing
segments of long lines is described. It is found that the band width of
an oscillating system with a variable capacitance is a function of the
sensitivity of the reactive circuit included in the system. Figures 7;
references 6: 4 Russian, 2 Western.
[213-6900]

PULSE-CODE AND DELTA-MODULATED SERIAL DIGITAL FILTERS

POGRIBNOY, V. A.

[Abstract] A method is proposed for using serial digital filters to reduce the number of long multipliers and shift devices, to replace multipliers with simpler logic elements and to reduce the number of shift device outputs. Pulse-code and delta-modulation serial filters are proposed and analyzed. The highest signal spectrum frequencies which the proposed filters can process are compared. Figures 3; tables 1; references 12: 8 Russian, 4 Western. [198-6900]

CODING EFFICIENCY IN IDEAL DOUBLE PHASE MODULATED CHANNEL WITH MEMORY WITH NONIDEAL SYNCHRONIZATION

KHATSKELEVICH, Ya. D., BEREZKIN, V. V. and YEGOROV, A. A.

[Abstract] The occurrence of inter-symbol interference in double phase modulated channels is estimated apart from phase and symbol synchronization error for different channel bases. The losses for a convolutional code with rates of R = 2/3, 3/4 and 4/5 are compared to nonredundant coding. It is found that convolutional coding makes it possible to relax the requirements for phase synchronization accuracy somewhat as compared with non-redundant coding for the same phase error. At the same time, the channels in question are less sensitive to small errors in symbol synchronization, and non-redundant coding provides smaller error than convolutional coding when the information base is fixed. The information provided may be helpful for selecting the code rate and channel information base, in setting synchronization accuracy and estimating the overall energy efficiency in channels employing convolutional coding. Figures 9; references: 3 Russian. [198-6900]

6B-4T BALANCED BLOCK CODE FOR DIGITAL TRANSMISSION SYSTEMS

LEV, A. Yu., MARKARYAN, G. S. and POKROPIVNYY, Ye. Ye.

[Abstract] A ternary balanced 6B-4T block code is proposed which can be
used to reduce the timing frequency of a linear signal by a factor of 1.5.
A code formation algorithm based on a finite automaton representation of the
code converter is presented. The synthesized code is compared with existing
versions and found to have a lower bit error propagation factor than MS43,
4B-3T and FOMT codes. The energy spectrum of the code is concentrated at
lower frequencies, and the density of the significant characters in the code
words is higher, which improves the timing properties of the code. The
results of the computer modeling are confirmed by tests performed on a proto-
type 6B-4T code converter. Figures 3; references 7: 5 Russian, 2 Western
(1 in Russian translation).
[198-6900]

SIGNAL DETECTION AGAINST BACKGROUND OF SPATIALLY DISPERSED NOISE

BOGDANOVICH, V. A. and VOSTRETSOV, A. G.

[Abstract] The problem of signal detection against the background of
spatially dispersed noise is solved for the case in which the signal
and interference represent quasi-determinate space-time functions with
unknown initial phases. The space-time properties of the signal-inter-
ference field in the antenna aperture are employed to synthesize the
decision rule. The proposed algorithm improves the tolerance of the working
characteristics to dispersed interference with insignificant losses in the
threshold signal-to-noise ratio. Figures 1; references: 4 Russian.
[198-6900]

ENGINEERING ESTIMATE OF RISE TIME OF SYNCHRONIZED FEEDBACK OSCILLATOR

ARTEMENKOV, S. L., BYCHKOV, M. I. and SMOL'SKIY, S. M.

[Abstract] The basic characteristics of the processes underlying the
establishment of synchronous oscillations are analyzed as a function of
the parameters of the external force and the feedback oscillation mode;
the influence of inertia of the active components on the duration of the
transient processes is investigated. A single-mode feedback oscillator
synchronized at the fundamental frequency of the current source in the out-
put circuit is examined. The results of computer analyses of the establish-
ment of the amplitude and phase of synchronous oscillations are discussed.
Figures 4; references: 3 Russian.
[198-6900]

NOISE IN LINEAR CIRCUITS CONTAINING OPERATIONAL AMPLIFIERS

LUR'YE, O. B.

[Abstract] A method is presented for finding the actual noise voltage,
referred to the input, in linear circuits incorporating operational
amplifiers containing a number of noise sources and feedback circuits.
An expression is derived for the output noise voltage and nominal signal
gain. Circuits with positive and negative feedback are analyzed, and
expressions are derived for determining their output noise voltage. The
input-referred noise voltage of an inverting amplifier incorporating an
operational amplifier with uniform spectral noise voltage density is
analyzed as an example. Figures 2; references 6: 5 Russian, 1 Western
in Russian translation.
[198-6900]

DIGITAL FREQUENCY SYNTHESIZER

BESKIN, L. N.

[Abstract] The individual digital frequency synthesizers employed in multi-
channel transmission systems and which serve the same function as the
oscillator equipment in traditional analog transmission equipment are
described. Recursive synthesizers are compared with table lock-up devices.
A recursive synthesizer with a recursion interrupt block is described in
which the accumulation of computational error is eliminated; and a group
digital frequency synthesizer is discussed which employs frequency recursion.
Figures 4.
[198-6900]

COMMUNICATIONS

RESULTS OF OPERATION OF "GALS" TYPE RADIOISOTOPE THERMOELECTRIC GENERATORS
ON EXPERIMENTAL IKM 120 LINE

SAVCHENKOV, Yu. P. and PTICHNIKOV, M. M.

[Abstract] Use of GALS type radioisotope thermoelectric generators based
on the commercially produced Beta-S generator to power unattended repeaters
on an experimental IKM-120 communications line is described. The sources of
electrical energy in these generators are solid state temperature transducers,
which exploit the temperature gradient of the surrounding air, and a module
containing a radioactive isotope. Decay of the isotope causes the module to
heat up, which transfers heat to a thermal battery, which is then converted
to electricity. The basic parameters of the source are presented. Opera-
tion of the sources confirmed their superior performance as self-contained
sources of electrical energy, which exhibit good reliability, stable
parameters, long service life and low maintenance costs. Figures 2;
references: 3 Russian.
[212-6900]

DIGITAL MODEM-9600 FOR VOICE GRADE CHANNELS

ASTAPKOVICH, K. F., BUYANOV, V. F., YEGOROV, V. A., ZHARENOV, V. A.,
ZAKHAROV, I. I., LOPATIN, S. I., NECHAYEV, V. M., PERFIL'YEV, E. P.,
PODGAYSKIY, A. G. and PONOMAREV, V. I.

[Abstract] The Modem 9600, designed for binary transmission at 9600 bits
per second over leased 4-wire voice-grade channels on cable, satellite and
radio relay lines up to 12,500 km long with no more than 5 audio frequency

repeaters, is described. The structural diagram and operating algorithm of the device are analyzed. The use of low-pass digital filters in the receiver is avoided by employing analog Hilbert transformation. Test results indicate that the parameters of the Modem-9600 correspond to MKKTT (International Telegraph and Telephone Consultive Committee) Recommendation V.29. The operating algorithms provide good noise tolerance for various distorting factors. Figures 4; tables 1; references 7: 6 Russian, 1 Western.
[212-6900]

PROBLEMS OF DEVELOPMENT OF SPACE COMMUNICATIONS

PETROVICH, N. T. and POROKHOV, O. N.

[Abstract] This article summarizes the Fifth All Union Scientific-Technical Conference on the problem of development of space communications which was held in September, 1983 at Kaluga. Over 100 reports were delivered in the area of satellite communications networks and their place in the primary consolidated automated communications network. Included were digital transmission methods; antenna devices; radio wave propagation; optical and microwave devices; communications system noise tolerance; synchronization systems; telemetry systems; data transmission; and searching for intelligent life throughout the Universe. The reports, and recommendations based on them, reflect the paths for further development of satellite communications systems.
[212-6900]

ALGORITHM FOR ENUMERATING MINIMAL PATHS IN COMMUNICATIONS NETWORK

KARPACHEV, V. Ye. and CHERVYATSOV, V. N.

[Abstract] An algorithm is proposed which employs expansion by variable of the function which assigns the initial graph of the network in conjunction with matrix notation of the function in order to enumerate the minimal paths with rank not exceeding an assigned value between any two nodes. The algorithm permits effective use of structural methods for analyzing complex networks in conjunction with machine methods for finding their reliability characteristics. Figures 1; tables 1; references 10: 7 Russian, 3 Western in Russian translation.
[212-6900]

EFFECTIVE THROUGHPUT CAPACITY OF SECTION OF PACKET-SWITCHING NETWORK WITH
INDEPENDENT ERRORS

ZVEREVA, G. I.

[Abstract] A frame handling algorithm based on MKKTT (International
Telegraph and Telephone Consultive Committee) Recommendation X.25 is
described in which received frames are acknowledged and erroneous frames
are repeated on the basis of exchanging numbered frames. A formula is
derived for the throughput capacity of the data transmission channel
affected by independent errors for the MKKTT algorithm for packet switching
networks. The throughput estimate provided is approximate because the
errors occurring in the communications channel are in general not
independent. Figures 4; references 3: 1 Russian, 1 Western in Russian
translation.
[212-6900]

INVESTIGATION OF FREQUENCY BEHAVIOR OF IMPEDANCE AND INDUCTANCE OF HV
BALANCE CABLES

LAKERNIK, R. M.

[Abstract] A method is proposed for investigating the frequency behavior
of the basic parameters of cables which permits the true additional
impedances and the inductance caused by the occurrence of eddy currents
in adjacent conductors and the sheathing to be found. The results are
examined of an experimental investigation of the frequency behavior of the
additional impedance and inductance of hf circuits carried on balanced
cables. It is found that the impedance of steel corrugated sheathing is
approximately 10 times higher than that of aluminum. The additional in-
ductance caused by eddy currents in the sheathing reduces the overall
inductance, i.e. it is negative. The experiments reveal that the empirical
formula customarily used to calculate losses in the conductors of adjacent
quads yields incorrect results, and that the formulas employed to calculate
losses in metal sheathing, especially corrugated sheathing made of ferro-
magnetic materials, needs to be refined. Figures 6; tables 1; references:
6 Russian.
[212-6900]

ELECTROMAGNETIC FIELD OF GROUP-TWISTED AND LAID TWO-WIRE LINE

DIKMAROVA, L. P. and PAVLYUK, R. P.

[Abstract] A general solution is obtained for the problem of the electro-
magnetic field distribution of a group-twisted and laid two-wire line with
allowance for the oscillating nature of the radial coordinate of the spiral
point of the line. The solution is obtained in a quasi-static approximation
with the assumption that the conductors are infinitely thin. Formulas are
derived for the voltage components of the electrical and magnetic fields of
group-twisted and laid balanced two-wire circuits. The results of computer
calculation of a two-wire twisted line are presented. Figures 3; references 5:
4 Russian, 1 Western in Russian translation.
[212-6900]

ANALYSIS OF DETECTOR CHARACTERISTIC OF PHASE DETECTOR FOR REAL SIGNAL SOURCE
AND LOAD

BEZRUKOV, A. V.

[Abstract] Expressions are derived which describe the detector characteristics
of phase detectors with allowance for the influence of the load capacitance
and the impedance of the signal source. It is found that impedance of the
signal source distorts the detection characteristic of a phase detector, and
that the null of the detector characteristic drifts for real load
capacitance values. The author thanks V. M. Sidorov for his remarks and
council which contributed to the improvement of the manuscript. Figures 1;
references: 3 Russian.
[212-6900]

NOISE TOLERANCE AND EFFICIENCY OF DATA TRANSMISSION SYSTEMS

BANKET, V. L.

[Abstract] A summary is provided of the activities of the Seventh Symposium on Noise Tolerance and Efficiency of Data Transmission Systems, held at Odessa in September 1983. This VIII Symposium was sponsored by the Central Administration of the Scientific-Technical Society for Electrical Engineering, Electronics and Communications imeni A. S. Popov, the Odessa Oblast and Moscow City Administrations of that Society and the Odessa Electrotechnical Communications Institute imeni A. S. Popov. One hundred six reports were delivered in the area of message transmission theory and practice and methods for improving the efficiency and noise tolerance of various types of communications systems. Special emphasis was placed on the practical utilization and implementation of new data transmission methods. A recommendation was adopted incorporating basic long term directions for further research. The IX Symposium is planned for 1986.
[212-6900]

50TH ANNIVERSARY OF MOSCOW CITY RADIO TRANSLATION NETWORK

MISHENKOV, S. L.

[Abstract] The history of the Moscow wired-radio broadcast network, which now provides over 5.3 million wired-radio outlets, with 647 outlets per 1,000 residents, is briefly traced from its inception in 1921. Growth statistics are presented for the period 1946-1982. Future modernization and expansion plans are outlined. Tables 1.
[212-6900]

DEVICE FOR INDICATING USABILITY OF TELEPHONE DIALS

TREST, A. I., chief designer, Central Design Office at USSR Ministry of Communications; Odessa branch, and CHAPLIK, V. M., master designer

[Abstract] Telephone dials must be periodically inspected for correct performance according to norms and specifications, which is now done by remote measurement of dial characteristics with a DINS-1 meter. This procedure is laborious, for a replacement of which there has been developed

and is now commercially produced a dial usability indicating device. This IGN-1 device analyzes the time characteristics of a dial simply and fast during a single turn, whereupon it indicates "accept" or "reject" on a display panel. Its most important component is the input stage, where "opening" and "closing" signals distorted by reactive elements in the arc suppressing circuit are converted to square pulses. The quality of this conversion determines the accuracy of dial usability indication. Square pulses are shaped by a circuit consisting of a transistor pair, a diode, and an emitter follower. The input stage includes further an amplitude selector, an amplitude limiter, a kipp oscillator, AND and OR logic, an RS trigger, a differential circuit, and a time delay. The input stage is followed by signal and flutter extractors with a signal counter, a scale-frequency generator and a modulator, a flutter indicator, two digital-to-analog converters with "opening" signal and "closing" signal counter respectively, and two voltage comparators with reference source each. This device measures time characteristics of dials accurately within +2%.
Figures 2.
[155-2415]

DEVICE FOR CONTINUOUS INSPECTION OF LONG-DISTANCE AUTOMATIC TELEPHONE COMMUNICATION CHANNELS

[Abstract] A device for continuous inspection of long-distance automatic telephone communication channels has now been developed at the Automation, Telemechanics and Communication Laboratory of the Belorussian Railroad system. It will replace the existing UPK-1 inspection device, which does not include means for automatic continuous operation. It consists of a transmitter and a receiver of test-frequency pulses, connected in parallel with the dial tone transmitter and receiver, respectively. The transmitter consists of a clock generator, a pulse duration forming circuit, a time interval forming circuit, and an output stage with resistive pulse voltage regulator and two capacitors. The receiver consists of an input filter-amplifier, a clock generator, a decade counter, a counter measuring the length of pauses between pulses, and a servo-mechanism. All components are built with transistors and microcircuits. The device generates an alarm signal and activates system interlocking in case of channel faults or excessive overall attenuation, an increase of the latter by more than 4.3 dB (0.5 Np) not being permissible. Figures 2; tables 1.
[155-2415]

USE OF SIMPLIFIED FUNCTIONAL SCHEMES FOR TRAFFIC CONTROL AT ESK 400E STATION

KHRAMCHENKOV, S. I., senior engineer, Automation, Telemechanics and Communication laboratory, Baltic Shoreline railroad

[Abstract] There are five basic programmed operations involved in establishing internal and external connections in a railroad telephone station. These are: 1) EB/TA program for connecting the caller to the cord set and the register; 2) WE/KT program for connecting the called subscriber to the caller; 3) WE/KA program for establishment of outgoing external communication; 4) RU program for connecting the register to the incoming trunk line relay; and 5) WE/KT/U program for establishment of connection to facilitate incoming automatic external communication. Existing schemes for execution of these programs can be simplified for use in the ESK 400E station with a TA-Su subscriber selector dial, a G-Est central control set, and W-Su-Zus line selector auxiliaries. These simplified schemes are for: 1) determination of the caller's address (subroutine 2.1); 2) interrogation of the central control set (subroutine 1); 3) determination of the cordset address (subroutine 3.1); 4) cut-in of the register (subroutine 6.2); and 5) transmission of the subscriber's address to the connector of the subscribers' sets. This is a continuation of an article in AVTOMATIKA, TELEMEKHANIKA I SVYAZ' No 1, Jan 84 and will continue in a later issue. Figures 6.
[155-2415]

METHOD OF TUNING DISCRETE-DATA CHANNELS EQUIPPED WITH FREQUENCY-DIVISION MULTIPLEX

GOFMAN, I. Ya., engineer, Artemovo track section, Donets Basin Railroad line, and BELINSKIY, P. N., senior electromechanic

[Abstract] A method of tuning discrete-data channels equipped with frequency-division multiplex has been developed and successfully introduced in the Artemovo track section. It yields the optimum ratio of transmission level to receiver-shaper threshold so as to ensure maximum interference immunity and maximum reliability. Its gist is setting the threshold, on the basis of oscillograph readings, above the transient overshoot voltage and below the minimum peak-distortion voltage. The oscillograph is, for this purpose, connected to the output coil of the tuning-fork filter through a free socket in the terminal board. The sensitivity and thus the operation threshold of the receiver-shaper is regulated by means of an adjustable resistor in the emitter circuit of the transistor stage through regulation

of the negative-feedback level. For tuning, this threshold regulator is initially set in the center position. Figures 4.
[155-2415]

INSPECTION AND REPAIR OF RECEIVERS FOR 'TYUL'PAN' AND 'DNEPR' PORTABLE RADIO STATIONS

LAPTEV, L. K., senior engineer, main administration of industrial railroad transportation, USSR Ministry of Railroads (MPS); and PICHUGIN, B. N., senior electromechanic, Klinskiy PPZhT [expansion unknown]

[Abstract] For inspection and repair of receivers for "Tyul'pan" and "Dnepr" portable radio stations one uses two intermediate frequency signals. The first one at 24 MHz is generated by a heterodyne consisting of a quartz oscillator with excitation at the third mechanical harmonic and a frequency quadrupler. The second one at 22.4 MHz is generated by a heterodyne of simpler construction and with better stability characteristics. After both heterodynes have been tuned, one proceeds tuning the high-frequency amplifier stage and the mixer stages. The 24 MHz difference-frequency voltage appears across the load on the first mixer, this load being a lumped-selection filter. The latter and the first intermediate-frequency amplifier are tuned by adjustment of the cores of coils, until the voltage at the limiter input becomes maximum and the low-frequency signal becomes perfectly symmetric. This is the conclusion of an article which began in AVTOMATIKA, TELEMEKHANIKA I SVYAZ' No 5, May 83. Figures 3.
[155-2415]

OPERATION OF STATIONARY RADIO STATION FOR TRAIN RADIO COMMUNICATION OVER SEVERAL ANTENNA SYSTEMS

GRANAT, B. S., chief, "Telemechanics and Radio Communication" coach-laboratory, Moscow Railroad line

[Abstract] Two or several antenna systems must be connected to a stationary radio station in a railroad switch yard in order to ensure a communication link between the railroad station attendant and all locomotive engineers throughout the switch yard. This problem is particularly serious when a waveguide must cross the railroad track. A scheme for connecting several antennas appropriately has been devised which includes an auxiliary output stage in parallel with the radio station transmitter and using a separate power supply. The high-frequency signal appears at the main receiver in the

radio station, while the output of the main transmitter is connected to a waveguide through a coaxial cable and a matching circuit and the auxiliary output stage is connected to an electrical antenna through a cable and an automatic control circuit. The automatic control circuit includes a transformer with a fixed series capacitor on the primary side and a variable shunt capacitor on the secondary side. As the auxiliary stage, it is most expedient to use a transmitter with all tubes except the last one removed. This scheme has been tested and then introduced in several stations along the Moscow railroad line.
[155-2415]

UNREGULATED BRIGADE APPROACH IN COMMUNICATIONS TOWER CONSTRUCTION

ZOLOTUKHINA, Ye. S., instructor in advanced methods of labor, Specialized Construction-Installation Directorate 173

[Abstract] The history of the unregulated brigade approach employed by Specialized Construction-Installation Directorate 173 (SSMU-173) is traced since its inception in 1976. Under the unregulated brigade method, sites at which the method is to be employed are identified at the beginning of each year, and an order to that effect is issued. The calculated cost of construction is then determined by the appropriate departments. Bringing in jobs on schedule and within budget depends entirely upon the performance and management of the brigade. The use of unregulated brigades has made it possible for SSMU-173 to shorten installation deadlines by 12% and improve quality by 10%. 48.8% of all work done by the Directorate in 1983 was performed by the unregulated brigade method. Figures 2.
[241-6900]

METHOD FOR DUPLEX TRANSMISSION OF DIGITAL INFORMATION

MALINKIN, V. B.

[Abstract] A new duplex data transmission method is proposed which allows the two transmission directions to be separated when the spectra are identical, and which provides approximately the same noise tolerance as classical relative phase modulation. A signal processing algorithm is constructed which compensates the signals of the local transmitter at the local receiver independently of the parameters of the two-wire communications line. A property of relative phase-shift keyed signals is identified which allows information to be transmitted and received in the same frequency band.

FLOWCHART DIAGRAM OF METHODOLOGY FOR OPTIMIZING COMMUNICATIONS SYSTEMS

SERVINSKIY, Ye. G.

[Abstract] The flowchart diagram of a methodology for optimizing communications systems developed in previous studies is examined. Analysis of the
flowchart diagram shows that the optimization methodology is axiomatic,
logically valid and internally consistent. The fundamental concept in the
optimization methodology is that of optimal resource distribution, in
accordance with which the system is characterized by two generalized
parameters - efficiency and cost - with the evaluation criterion being
the value of one of the generalized parameters (which therefore becomes
criterial); the optimization procedure consists of finding the extremum of
the criterial parameter. [The manuscript of this paper, which contains
13 pages of text, 1 figure, 1 table, and 22 bibliographic items, can be
ordered at TSNTI, "Informsvyaz'" where it is stored under No. 291.]
Figures 1; tables 1.
[198-6900]

CORRELATION RECEPTION IN REAL CHANNEL

SENDERSKIY, V. A.

[Abstract] The influence of irregularity in the amplitude-frequency characteristic on the noise tolerance of correlation reception in a real channel is
examined. An expression for the signal-to-noise ratio at the output of a
correlation receiver is derived. The analysis is also valid for matched-
filter reception, because the correlation integrals found by a correlator
and a matched filter agree to within a constant. Four special cases are
presented as examples. Figures 1; references: 4 Russian.
[198-6900]

COHERENT PROCESSING OF NARROW-BAND SIGNALS IN CHANNELS WITH BURST NOISE

BELOV, P. V. and ORLOV, V. I.

[Abstract] Reception noise tolerance in channels with burst noise is
investigated statistically. The effectiveness of temporal processing in-
corporating coherent addition of the valid signal and suppression of inter-
ferenceiis compared with that of processing circuits which only add the
signal; it is found that interference compensation is the main factor which
determines reception noise tolerance. The degree of coherence in adding the
valid signal has little effect. It is best therefore to employ systems
which compensate for burst noise in heavily used channels. Figures 1;
references 3: 1 Russian, 2 Western.
[198-6900]

LOWER BOUND OF ERRONEOUS DECODING PROBABILITY

SHAPTSEV, V. A.

[Abstract] The lower bound of the erroneous decoding probability is investi-
gated for optimal reception of orthogonal binary signals with identical
energy. The channel is assumed to be linear and symmetrical; the fluctuations
in the parameter are described by a Nakagami-Rice distribution. Expressions
are derived for the exact and approximate lower bound of the erroneous
decoding probability. Computational results are presented and analyzed.
Figures 1; tables 1; references 4: 3 Russian, 1 Western.
[198-6900]

SIGNAL RECOGNITION BASED ON MULTI-BASIS REPRESENTATIONS

DANIYEV, Yu. F. and RYZHOV, V. P.

[Abstract] Use of multi-basis representation, i.e. representing the signal
simultaneously in several basic systems in order to shorten signal

descriptions (in relation to expansions in a nonoptimum basis), without requiring substantial operator information, is described. The set of bases which can be used to minimize computation in digital signal processing is the piecewise constant set of Walsh, Haar, Rademacher and other functions. The use of multi-basis representation is illustrated by an example of a spectral domain signal recognition problem. It is found that the use of multi-basis systems decreases the number of features needed, thus decreasing computational costs, or increasing recognition accuracy for given costs. Tables 1; references: 2 Russian.
[198-6900]

ANALYSIS OF CORRELATION PROPERTIES OF EXPANSION OF COMPLETE CODE OF FM SIGNALS INTO CONTIGUOUS CLASSES

SAL'NIKOV, Yu. K.

[Abstract] An analysis is performed in order to identify the better, in terms of correlation properties, of two different expansions of a complete code into linear derivative systems (contiguous classes). The average distribution moment of the correlation function for the ensemble of systems is computed. It is found that the complete code includes linear derivative systems with good correlation properties. A formula is derived by which different expansions of the complete code can be compared, and the best selected according to the minimum values of the moment. References: 6 Russian.
[198-6900]

ANALYSIS OF RECEPTION NOISE TOLERANCE OF PULSE SIGNALS WITH NONSINUSOIDAL CARRIER

TRIFONOV, A. P. and SENATOROV, A. K.

[Abstract] The noise tolerance is examined of some types of pulse modulation with carrier oscillation consisting of a rectangular Walsh function. The output signal-to-noise ratio is found to increase in the same way for pulse-width, pulse-position and sequential-pulse modulation. The use of a sinusoidal carrier results in half as large an increase in the output signal-to-noise ratio. A particular type of nonsinusoidal carrier modulation can be selected

by comparing the noise tolerance characteristics derived for a specific digital transmission condition and given modulation parameters.
[The manuscript of this paper, which contains 9 pages of text, 3 figures, and 6 bibliographic items, can be ordered at TSNTI, "Informsvyaz'" where it is stored under No. 294.] References 4: 2 Russian, 2 Western in Russian translation.
[198-6900]

GRAPHIC ANALYSIS METHOD FOR ADAPTIVE NOISE COMPENSATION ALGORITHMS

GERTSENSHTEYN, M. Ye. and LEVINZON, F. A. and ZYUZIN, V. N.

[Abstract] Active noise compensation by a multichannel receiving device with a different signal-to-noise ratio in each channel but the same noise level in all channels is examined. A control algorithm is constructed which projects the input vector in the direction orthogonal to the input vector, which for d = o is orthogonal to the direction of the noise, i.e. the noise is completely suppressed. [The manuscript of this paper, which contains 16 pages of text, 10 figures, and 20 bibliographic items, can be ordered at TSNTI, "Informsvyaz'" where it is stored under No. 267.] Figures 2; references: 3 Russian.
[198-6900]

COMPONENTS, HYBRIDS AND MANUFACTURING TECHNOLOGY

DISTRIBUTED-GAIN AMPLIFIERS EMPLOYING POWERFUL INSULATED-GATE FIELD-EFFECT TRANSISTORS AND M-TYPE FILTERS

SMERDOV, V. Yu. and ADAMOV, P. G.

[Abstract] The performance of an IGFET distributed-gain amplifier employing M-type filters is analyzed. The operation of a circuit employing five KP905 transistors is analyzed. It is found that the distributive-gain IGFET amplifiers are promising for wideband amplifiers with transient response rise times of less than one nsec and pulse amplitudes of several volts. Figures 2; references: 3 Russian.
[236-6900]

ELECTRONIC CONTROL RELAYS FOR STUDIO AMPLIFIERS FOR EQUIPMENT OF CONFERENCE COMMUNICATION

TRET'YAKOV, L. P., section chief, Barabinsk Section, West Siberian Railroad

[Abstract] The use of electronic analogs to replace the RES-6 control relay and RP-4 reverse control relay employed in studio conference equipment amplifiers. The schematic diagram of each of the fully transistorized relay circuits is traced and explained. Each circuit fits on a 3.5 x 5 cm circuit board. An RES-6 relay serves as a backup for the electronic control relay.
[246-6900]

HIGH-FREQUENCY SWITCH

MOSTYKO, V. S.

[Abstract] The schematic diagram of a high-frequency switch incorporating
four transistors and two transformers is described. The switch employs
negative feedback in order to expand the dynamic range of the signal.
Testing of the switch with a 50 MHz signal indicates that the switching
spike and signal level during pauses is 50-60 Db, which is the same as the
dynamic range of the input signal. Figures 1; references: 1 Russian.
[198-6900]

COMPUTERS

THE ART OF PROGRAMMABLE MICROCALCULATOR PROGRAMMING. 9. MATHEMATICAL
PROGRAMMING

TROKHIMENKO, Ya. K.

[Abstract] The use of programmable calculators to implement minimization
methods is explained. Linear and nonlinear programming algorithms in
programs for microcalculators are presented which implement the "golden
mean", uniform serial search, variable partial coordinate descent, spiral
coordinate descent and other methods are presented. References: 6 Russian.
[192-6900]

THE ART OF PROGRAMMING PROGRAMMABLE MICROCALCULATORS, PART 10: NUMERICAL
SOLUTION OF SYSTEMS OF EQUATIONS

TROKHIMENKO, Ya. K. and LYUBICH, F. D.

[Abstract] Algorithms and programs for finding the roots of systems of
linear and nonlinear equations using programmable microcalculators are
presented. A version of the Gaussian exclusion method based on transforming
an initial system of indirect steps to triangular form is described. Pro-
grams are described for computing the roots of a system of three linear
equations by the single division scheme, for solving a system of $N \leq 4$ and
$N = 5$ linear equations by the optimal exclusion method, for transforming the
coefficients of a system of linear equations by the Jordan method, and for
solving a system of nonlinear equations by the Newton method. Tables 1;
references: 5 Russian.
[236-6900]

MEMORIES OF MICROPROCESSOR SYSTEMS

SOROKIN, B. L., candidate of technical sciences, senior scientific worker, and YABLONSKIY, S. A., candidate of technical sciences, senior scientific worker, Leningrad Order of Lenin Institute of Railroad Transportation Engineers imeni Academician V. N. Obraztsov (LIIZhT)

[Abstract] Internal microprocessor memories, both direct-access ones and read-only ones, are reviewed with regard to register arrays and functional design, volume and speed considerations, hardware and technology of logic circuitry for digital large-scale integration, and software in terms of algorithmic structure and programming methods. Figures 6; tables 6; references: 4 Russian.
[155-2415]

INSTRUCTION/DATA REPRESENTATION AND ADDRESSING METHODS IN MICROPROCESSOR SYSTEMS

LOKHMATYY, V. Ye., docent, Leningrad Institute of Rail Transport Engineers, candidate of technical sciences, TRAN'KOV, S. N., engineer

[Abstract] Methods for representing data and instructions for the KR580IK80A microprocessor are described. This microprocessor can accommodate unsigned 8-bit integers from 0 to 255, or signed 8-bit integers ranging from -128 to +127. Negative numbers are represented in complement code. Unsigned 16-bit integers can also be represented ranging from 0 to 65535. The KR580IK80A microprocessor instructions consist of 8-bit words (bytes), or may consist of two or three bytes, in which case the bytes which make up a single instruction are stored sequentially in memory. Methods for addressing data, instructions and peripheral devices are outlined, including immediate addressing, direct addressing, register direct addressing, register indirect addressing, and implicit addressing. The instruction set of the KR580IK80A, which contains 111 instructions, is presented, along with a description of the operation of individual instructions. Instructions not included in the present article are scheduled for future publication. Tables 3 and 3 extensions; references 2: 1 Russian; 1 Japanese in translation.
[246-6900]

FACET-BEAM METHOD FOR CALCULATING ENERGY REFLECTION CHARACTERISTICS OF THREE-DIMENSIONAL BODIES

MATSHIN, R. M., NEPOGODIN, I. A. and KUROCHKINA, Ye. Ya.

[Abstract] A numerical method for calculating the energy reflection character-
istics of three-dimensional bodies is examined which can be used for computer
calculation of bodies with arbitrary shape and with arbitrary surface scatter-
ing properties. A surface of the body is represented as a set of a finite
number of sufficiently small areas, or facets, which are flat reflecting
scatterers; in the absence of shading, these contribute (directly or through
rereflection) to the combined optical signal reflected toward the entrance
pupil of the receiving system. A FORTRAN program which implements the
facet-beam method is described, and the analysis of the effective reflecting
area of a cylinder is presented. Figures 1; references 7: 5 Russian,
2 Western.
[198-6900]

ELECTRICAL INSULATION

LOCATING WEAK SPOT IN INSULATION SYSTEM

KOSTYGIN, V. N., electromechanic, and KAPRALOV, V. A., electromechanic, Buysk track section, Northern Railroad line

[Abstract] A method of locating an insulation fault with a Varley loop tester has been devised which simplifies both the measurements and the calculations. It is based on balancing the bridge, which has equal resistances in the two fixed arms. The method indicates a fault in either of the two cable segments and reveals which cable segment if faulty. The method has already been used in the field for over a year. Figures 1.
[155-2415]

ELECTRON DEVICES

COMPUTER INVESTIGATION OF EFFECTS OF HIGH INJECTION LEVEL IN TRANSISTOR
LARGE INTEGRATED CIRCUIT STRUCTURES

BUBENNIKOV, A. N.

[Abstract] The effects of collector and emitter base expansion, base
conductivity modulation, and static ejection and accumulation of carriers
at the periphery of the emitter junction are investigated. The electrical
characteristics of a transistor structure are analyzed on a BESM-6 computer
by means of unidimensional and two dimensional physical-topological programs.
The results can be used to make a valid choice of the electrical mode of
transistor structures and elements, and to facilitate normal functioning
of LIC with the required speed and without significant degradation of
parameters. Figures 3; tables 1; references 4: 3 Russian, 1 Western.
[236-6900]

NUMERICAL ESTIMATION OF CHARGE TRANSFER TIME IN CHARGE-COUPLED DEVICE
EMPLOYING LATENT GALLIUM ARSENIDE CHANNEL

PROKOP'YEV, A. I.

[Abstract] Charge transfer inefficiency is analyzed as a function of time
in latent-channel gallium arsenide CCD devices and Schottky-barrier gates
for three transfer mechanisms - boundary field, self-induced drift and
diffusion. Allowance is made for the drift rate saturation effect, and the
relative contribution of each of the three mechanisms to charge transfer
is assessed. It is found that allowance for drift rate saturation has an
influence on the form of the transfer inefficiency curves. The transfer

occurs in two phases, with self-induced drift controlling the first phase an with the transfer rate depending nonlinearly upon the boundary fields in the second phase. Figures 1; references: 5 Western (1 in Russian translation). [236-6900]

HIGH-SPEED POWER THYRISTORS WITH EXCELLENT SWITCHING AND LOAD CHARACTERISTICS

KUZ'MIN, V. L., candidate of technical sciences, RUKHAMKIN, V. M., candidate of technical sciences, and TOOMLA, O. K., candidate of technical sciences, Tallinn Electrical Equipment Manufacturing Plant imeni M. I. Kalinin

[Abstract] A new generation of high-speed power thyristors is being developed, with standard PNPN structure in stud configuration (three diameters 18-24-32 mm with current rating 50-200 A) and in pellet configuration (three diameters 32-40-50 mm with current rating 200-800 A). Branching the control electrode and the internal amplification of the signal raise the safe maximum di/dt and thus improve the load characteristics, but only at frequencies above 1.5 kHz and correspondingly high switching speeds with low turn-on losses. The main design features are in involute control electrode and mesa positioning of the amplifying control electrode, combined with 20 μm thick Al metallization of cathode and p-base. Design and performance calculations are based on known relations for exponential current rise, power losses, and temperature rise in accordance with the equivalent circuit. These TB and TBK thyristors will completely replace existing TCh, TChI, TB devices. Figures 4; tables 1; references 9: 2 Russian, 2 Hungarian, 5 Western (1 in Russian translation).
[235-2415]

HIGH-POWER GATE TURN-OFF THYRISTORS

AYAZYAN, R. E., engineer, Physicotechnical Institute imeni A. F. Ioffe, USSR Academy of Sciences

[Abstract] A gate turn-off thyristor is a more efficient energy converter than a transistor, but it is slower than a transistor and has a larger forward voltage drop than a plain thyristor. A major factor limiting the applications for GTO thyristors has been their low power rating. This

obstacle is being overcome by the development of high-power GTO thyristors. A theoretical basis has been available since 1960, including a thorough phenomenological analysis of the turn-off process. This process is both non-uniform and nonsteady, which limits injection and narrows the conducting region laterally. A high-power GTO thyristor is essentially an integral structure consisting of very narrow thyristor strips connected in parallel, with cathode n-emitters embedded in the p-base region. The contradictory requirements of high turn-off gain $K_{TO} = I_{A,TO}/I_{CG,min} = \alpha_1/(\alpha_1 + \alpha_2 - 1)$ ($I_{A,TO}$- anode current to be turned off, $I_{CG,min}$- minimum cathode-gate current required for turning off, α_1- current gain of NPN transistor and α_2- current gain of PNP transistor in equivalent two-transistor circuit) and low emitter-junction breakdown voltage can be resolved by a tradeoff between α_1 and α_2, with precisely controlled doping of the p-base adjoining the n-emitter. Experimental data indicate that optimization of GTO thyristors for efficient turn-off of high anode currents under high voltages requires a large V_{bdJ_1}/R_B ratio (V_{bdJ_1}- breakdown voltage of n-emitter junction J_1, R_B- resistance of p-base), attainable through maximization of the emitter doping and minimization of the emitter width. It also requires a low concentration of excess charge carriers stored in the n-base adjacent to the anode p-emitter, attainable by means of a leakage path in the p-emitter junction J_3. Another important problem is the temperature rise during switching, which can be lowered by means of a damping circuit (inductance - diode shunted by resistance - capacitance, in series across the thyristor) which will accelerate the turn-off process and at the same time limit the dV/dt during fall of the anode current. Figures 7; tables 1; references 31: 11 Russian, 20 Western.
[235-2415]

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TRENDS IN DEVELOPMENT OF BIPOLAR POWER TRANSISTORS

POTAPCHUK, V. A., candidate of technical sciences, All-Union Institute of Electrical Engineering imeni V. I. Lenin

[Abstract] Monolithic integrated-circuit technology is applied to bipolar power transistors, including Darlington transistors with preamplification. They are produced generally with two stabilizing resistors and sometimes also with two diodes for higher switching speed and for overvoltage protection respectively. Darlington transistors have higher current gain than plain silicon transistors of the same size so that, despite their lower collector-emitter saturation voltage and longer current fall time, they are indispensable for inverters. The main trend and corresponding changes in manufacturing methods are toward higher current and voltage ratings for direct connection without step-down transformers, the switching power being $P_{sw} = I_{C(sat)} \cdot V_{CEO}$.

At the same time, owing to broad applications combined with higher allowable collector current densities and shorter switching times, still 80% of all power transistors now produced have ratings $I_{C(sat)} < 30$ A and $V_{CEO} < 200$V. These devices are produced by enterprises which earlier produced transistors with current ratings below 10 A and can rather easily convert the production tools for a relatively moderate change. Low-voltage transistors with thin low-resistivity epitaxial layers have the optimum combination of performance characteristics, while most transistors with ratings up to 50 A and 400 V have $n-n^+$ epitaxial structures. Insertion of one or two thin moderately doped layers between the lightly doped epitaxial layer and the heavily doped substrate results in a more favorable electric field distribution immune to the defective intermediate region at the metallized surface of the $n-n^+$ junction, which is an effective way to produce transistors for voltages up to 1000 V. Triple diffusion is still more successful than the epitaxial process in producing high-current high-voltage transistor structures and is, therefore, the predominant technology, although General Electric already produces multilayer epitaxial transistors for $I_{C(sat)} \geq 50$ A and $V_{CEO} \leq 500$ V. By triple diffusion one can produce high-voltage (up to 3000 V) low-current (up to 10 A) transistors for communication (color television) rather than power equipment, which requires a large active emitter area. This is attained by increasing the chip size or allotting up to half the chip area to the emitter, at a sacrifice in switching speed because of the larger thickness of active layers and attendant longer lifetime of minority carriers in them. Consequently, bipolar lower transistors for voltages higher than 1000 V are not likely to be produced soon. Figures 5; tables 1; references 7: 3 Russian, 4 Western.
[235-2415]

HIGH-SPEED POWER DEVICES WITH FIELD CONTROL

GORYUNOVA, O. F., candidate of physico-mathematical sciences, and KUZ'MIN, V. A., doctor of physico-mathematical sciences, All-Union Institute of Electrical Engineering imeni V. I. Lenin

[Abstract] A generation of high-speed power devices is appearing in which some fundamental deficiencies of transistors (low overload capacity, secondary breakdown, low large-signal gain, unsuitability for parallel connection except in the Darlington configuration with undesirable high ON-resistance) have been overcome. Injection devices with better characteristics are bipolar transistors for high pulse currents (up to 350 A) but low voltages (up to 450 V) and for high voltages (up to 1200 V) but low currents (up to 10 A) with switching frequencies up to 20 kHz. Other injection devices are gate turn-off thyristors for 600-1200 V and up to 450 A with switching

time down to 5 µs or for 2500 V and up to 600 A with longer switching time
of 15 µs. New devices are field-effect transistors and electrostatically-
controlled thyristors. Field-effect transistors are MOS devices featuring
high speed with nanosecond switching time, high input impedance, small
control current, and a negative temperature coefficient of drain current.
Structurally they are produced with either vertical or horizontal conduction
channel, both versions operating by the same principle and their cost
still being high. Electrostatically-controlled thyristors are p-nn$^+$
diodes with n$^+$-cathode regions interspersed by p$^+$-grid regions. Structurally
they are produced with either surface grid or buried grid, the switching
characteristics being better but the gain being lower with a surface grid.
Their present ratings are: 1) 500 V - 10 A, switching time shorter than 1 µs;
2) 800 V - 100 A, switching time shorter than 1 µs; 3) 1000 V - 100 A,
switching frequency higher than 15 kHz; 4) 2500 V - 500 A, switching time
6 µs. A comparative evaluation of all these new devices reveals that GTO
thyristors have the highest load (current) capacity and field-effect
transistors have the highest switching speed. A promising further develop-
ment is combining different devices as, for instance, an MOS transistor in
the input stage with a bipolar transistor or thyristor in the following
stage. Figures 7.
[235-2415]

SEMICONDUCTOR HIGH-VOLTAGE POWER DEVICES: STATE OF ART AND OUTLOOK

BORONIN, K. D., candidate of technical sciences, YEVSEYEV, Yu. A., doctor
of technical sciences, LOKTAYEV, Yu. M., engineer, SOBOLEV, N. A., candidate
of physico-mathematical sciences, TUCHKEVICH, V. M., academician (USSR
Academy of Sciences), and CHELNOKOV, V. Ye., doctor of technical sciences,
Physicotechnical Institute imeni A. F. Ioffe, USSR Academy of Sciences

[Abstract] A survey of data on existing superhigh-voltage silicon devices
indicates the feasibility of such devices having a breakdown voltage as
high as 5 kV at a forward current density of the order of 100 A/cm^2 when
designed for a switching time not exceeding 300-500 µs and a forward voltage
drop not exceeding 2-2.5 V. Further theoretical and experimental studies
indicate that it is possible to improve these ratings, specifically to raise
the breakdown voltage into the 10-20 kV range. This can be achieved by
several methods such as better purification of raw silicon and its neutron
doping so as to minimize the variance of electrical resistivity, ensuring
retention of its electrophysical properties during subsequent technological
treatment, regulating the lifetime of charge carriers by irradiation and
regulating their surface concentration. All these methods utilize the
physical characteristics of a p$^+$nnp$^+$-structure, particularly dependence of
the forward current-voltage characteristic and the switching speed of silicon

devices on the dimensions of this structure and on the charge concentration
profile in it. Tests and measurements performed on prototypes indicate
that the optimistic forecasts based on calculations are quite reliable.
Figures 4; references 15: 14 Russian, 1 Western.
[235-2415]

NEW METHODS OF FAST SWITCHING OF HIGH POWER BY MEANS OF SEMICONDUCTOR
DEVICES

GREKHOV, I. V., doctor of physico-mathematical sciences, professor,
Physicotechnical Institue imeni A. F. Ioffe, USSR Academy of Sciences

[Abstract] The main drawbacks of gas-discharge tubes as switching devices
are their trigger instability, short life, intricacy of equipment, and
sensitivity to external perturbations. They are, moreover, incapable of
switching high power in subnanosecond time. In view of this, new concepts
of fast high-power switching and three new devices have been recently
developed in the Laboratory of Semiconductor Power Devices at the
Physicotechnical Institute imeni A. F. Ioffe. The silicon power thyristor,
the most suitable device for microsecond switching, features uniform and
simultaneous injection of excess charge carriers into the base regions so
as to ensure optimum switching over the entire active area, with a concen-
tration of excess charge carriers much higher than the minimum necessary for
triggering so as to prevent pinch-off. The silicon power optothyristor, with
an electron-hole plasma built up directly in the space-charge region of the
collector junction by action of a neodymium laser (wavelength 1.06 μm close
to the absorption line of silicon, is the most suitable device for nano-
second gigawatt switching). In the emitter with metallized contact, occupy-
ing the upper surface of the thyristor structure, are a few thousand pin-
hole windows with a total area approximately half the active surface area.
A laser pulse impinging on the entire surface causes plasma columns to form
simultaneously under all windows so that the current can spread over the
entire p^+-emitter. The fast-recovery drift diode, connected in parallel
with the load and acting as a pulse peaking circuit, is much simpler but
has also a much lower power capacity. Its switching time can, however,
be shortened from nanoseconds into the subnanosecond range by postponement
of avalanche breakdown. Application, in quick succession (within a few
nanoseconds) of a quasi-steady reverse bias voltage and a rising pulse in
the same direction will prevent impact ionization even under a forward
voltage 50-100% above the avalanche breakdown level. Only a still higher
voltage will expand the space charge into the neutral region and cause
drift of holes, followed by ionization over the entire diode volume with
avalanche occurring within 10^{-11} s under a voltage rising at a rate of
10^{12} V/s so that a dense electron-hole plasma forms in the nonconducting

region within a time much shorter than the transit time of charge carriers drifting at their maximum possible velocity. Such a device can switch a current of 30 A under a voltage of 3 kV within 0.1 ns. Figures 8; references 6: 5 Russian, 1 Western.
[235-2415]

GALLIUM-ARSENIDE POWER DEVICES

ALFEROV, Zh. I., academician (USSR Academy of Sciences), TUCHKEVICH, V. M., academician (USSR Academy of Sciences), and CHELNOKOV, V. Ye., doctor of technical sciences, Physicotechnical Institute imeni A. F. Ioffe, USSR Academy of Sciences

[Abstract] A survey of available data indicates the feasibility of producing GaAs power devices much smaller in volume and mass than silicon devices of the same power rating, with a much shorter switching time. This is attributable to the higher critical electric field intensity for breakdown of GaAs junctions and the correspondingly higher concentration of the majority-carrier N-impurity. The governing factor is the effective thickness of the p-base, smaller than that of the n-base in silicon structures and comparable GaAs structures or equal to it in GaAs structures with symmetric bases. In the latter case the p-base is still thinner and the lifetime of minority carriers is still shorter for a given ratio W/L of effective base (thicker) width to effective diffusion distance. This bears on the magnitude of the voltage drop produced by modulation of the base resistivity depending almost solely on the W/L ratio as well as of the voltage drop produced by electron-hole scattering and Auger recombination depending principally on the effective base thickness. Estimates for GaAs diodes with p^+pnn^+-structures, based on empirical relations and experimental prototypes, indicate a forward voltage drop not exceeding 2.1 V at a current density of 750 A/cm^2 in 80% of devices with W/L = 3. Factors favoring further development of GaAs devices in preference to silicon devices are not only higher current densities and correspondingly smaller dimensions as well as more ideal switching and transient characteristics but also much lower temperature and much shorter time of the epitaxial process (diffusion technology not being applicable here) with complete elimination of mechanical treatment, and zero waste of material with GaAs used only as a heavily doped substrate. Figures 4; tables 3; references 9: 8 Russian, 1 Western.
[235-2415]

INTEGRATED POWER DEVICES WITH THREE-DIMENSIONAL CONNECTION FOR AUTOMATION SYSTEMS

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[Abstract] Two integrated semiconductor power devices utilizing the physical characteristics of three-dimensional processes in PNPN structures during switching are the multiposition switch and the forwistor. The former is a chain of PNPN elements closely spaced apart in a single chip with three-dimensional coupling, tangential currents in the common base layer serving as control currents for neighboring elements in the OFF state. The latter consists of two two-layer pn-sections on a common two-layer pn-base, each section having a cathode and one section having two gates, coupling between the two sections being effected along a small segment of their common boundary. Both devices feature a moving low-resistance region for aniso-tropic coupling, just moving forward or back-and-forth or expanding from one end to the other. In the multiposition switch the density of the tangential control current increases with increasing current in the ON element until that current reaches its critical level for switching. In the forwistor a control current pulse turns on first section and then the other, the critical turn-on current for the second section depending on the density of the turn-off control current, on the area of the first section, on the width of the separating segment, on the thickness of both base layers, on the lifetime of charge carriers, and on the temperature. The velocity of the turn-on front and thus the turn-on speed of the second section can be regulated by the turn-off current fed to the base through one of the gates of the first section. The forwistor is switched off by reversal of the polarity of the applied voltage. This device can be used as amplitude-to-time converter. Its numerous applications as a simple and reliable device in automatic control systems include secondary power supplies, triple-loop voltage regulation, two-step power regulation, pro-tection of primary and secondary power supplies, inspection and fault indication. Figures 5; references: 5 Russian.
[235-2415]

DEVELOPMENT OF TECHNOLOGY OF SILICON SINGLE-CRYSTAL PRODUCTION FOR
SEMICONDUCTOR POWER DEVICES: STATE OF ART AND OUTLOOK

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Research and Planning Institute of the Rare Metals Industry)

[Abstract] At the present time over 75% of all semiconductor silicon is
produced by the Czochralski process using a quartz crucible and a graphite
heater, this method being most suitable for single-crystals more than 100 mm
in diameter. These silicon single-crystals have a high oxygen and carbon
content (up to $2 \cdot 10^{18}$ cm^{-3} and $3 \cdot 10^{17}$ cm^{-3}, respectively), however, so that
the trend is toward the floating-zone process yielding silicon single-
crystals with not more than $5 \cdot 10^{16}$ cm^{-3} oxygen and carbon concentration.
Other recently developed processes for subsequent treatment are neutron
transmutation doping of silicon with pohsphorus in order to ensure a high
uniformity of electrophysical properties needed in high-voltage devices.
Silicon is irradiated with reactor neutrons and during the (n,γ)-reaction
the ^{30}Si isotope absorbs thermal reutrons, whereupon the unstable ^{31}Si iso-
tope converts into ^{31}P. The inevitable radiative defects must be sub-
sequently cured by annealing. This technology imposes stringent requirements
on the silicon material as well as on both the doping and annealing processes.
The trend is, accordingly, toward better purification of the polycrystalline
raw silicon and of the argon atmosphere used for the floating-zone process,
along with better hermetization and sterilization of the equipment. Re-
search on optimization of the doping process is still in early stages, with
available data on optimum temperatures (50-60°C) and cadmium number (50)
indicating that a highly sterilized water-graphite channel reactor using
uranium fuel is the most suitable facility for this purpose. Optimization
of the postirradiation annealing process has not yet been finalized, but
measurements by various methods (electron-paramagnetic resonance, low-
temperature photoluminescence, infrared spectroscopy, deep-level trap
spectroscopy) have yielded a wealth of useful data. An important factor
in further developments will be the availability of means for accurately
and reliably determining macro- and microinhomogeneities in doped materia.
References 31: 17 Russian, 14 Western (1 in Russian translation).
[235-2415]

PROPERTIES OF SILICON DOPED IN RBMK-1000 MW WATER-GRAPHITE CHANNEL REACTOR
OF CHERNOBYL' AES

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candidate of physico-mathematical sciences, KOZLOV, V. A., engineer,
PETROV, Yu. V., candidate of physico-mathematical sciences, SOBOLEV, N. A.,
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professor, and SHLIMAK, I. S., doctor of physico-mathematical sciences,
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[Abstract] Large specimens of silicon for semiconductor power devices and
large-scale integrated-circuit devices were experimentally doped by the
neutron transmutation process in the RBMK-1000 MW water-graphite channel
reactor of the Chernobyl' AES. This 1981-82 project was participated in by
scientists from the Physicotechnical Institute (USSR Academy of Sciences),
the Leningrad Institute of Nuclear Physics, and the State Scientific Re-
search and Planning Institute of the Rare Metals Industry (GIRedmet). The
quality of specimens thus doped, particularly the uniformity of their
electrical resistivity, depended largely on the reactor operating
parameters as well as on the characteristics of the raw material. Into
consideration, therefore, had to be taken the radial distribution of the
neutron flux, characterized by a wide plateau extending over 4.5 m from the
reactor axis and a narrow lower peak at the edge of the reactor core ad-
joining the reflector at the location of fission triggering chambers.
Cylindrical specimens up to 150 mm long and 50 mm in diameter were placed in
both zones of maximum neutron flux, in water-cooled channels of the control-
and-protection system. Another consideration was the "soft" neutron energy
spectrum with a large ratio of slow neutrons needed for transmutation doping
to fast neutrons causing undesirable and even unannealable defects (50:1 in
reactor core, 1000:1 in reflector channels). For comparison, specimens were
also irradiated in a VVR-Ts water-moderated water-cooled reactor with an
only 10:1 ratio of slow neutrons to fast neutrons. As intrinsic material
was used both n-type and p-type silicon, dislocation-free, with 150-250 μs
lifetime of charge carriers and over 30% nonuniformity of electrical re-
sistivity in low-resistivity specimens (400-500 ohm.cm) as well as in high-
resistivity specimens (500-5000 ohm.cm). As a result of doping with trans-
mutation to phosphorus, the mean electrical resistivity of all specimens
was reduced to 20-80 ohm.cm while the nonuniformity of electrical resistivity
was reduced to 1.5% over the diameter and 8% over the length in low-
resistivity specimens, only to 5% and 15%, respectively, in high-
resistivity specimens. For comparison, specimens of n-type silicon grown by
the floating-zone method were doped with boron and aluminum by the diffusion
process and their electrical resistivity of 1300-2000 ohm.cm was only reduced

to 210 ohm.cm as a result. Devices with p^+pnpn^+-structures and devices
with pnp-structures were built with silicon doped by neutron transmutation
and then tested with satisfactory results. Figures 6; references 16:
13 Russian, 3 Western (1 in Russian translation).
[235-2415]

AUTOMATED DEVELOPMENT AND DESIGN OF SEMICONDUCTOR POWER DEVICES

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candidate of physico-mathematical sciences, and YURKOV, S. N., candidate
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imeni V. I. Lenin

[Abstract] The process of developing and designing semiconductor power
devices has been automated by use of a computer with SRV time division,
scientific calculation programs written in FORTRAN, user-machine dialog by
DISFORT system, GRAFIKA programming of machine graphics, INES (Institute
of Electronic Machines) database control, and UPRAVLENIYE development run
control. All these components are invariant. The operation between data-
base and development run control is subdivided into 8 task groups: design,
analysis, topological photo-layout, patent search, cost determination and
economics, quality and competitiveness evaluation, catalog search for equi-
valent foreign product items, and forecast of production statistics on the
basis of nominal device parameters with structural nonuniformity of electro-
physical properties taken into account. The performance of this automatic
development and design system is illustrated on a typical high-voltage
power thyristor. Figures 2; references: 7 Russian.
[235-2415]

CURRENT-VOLTAGE CHARACTERISTICS OF SEMICONDUCTOR POWER DEVICES OPERATING
AT HIGH CURRENT DENSITIES

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[Abstract] The forward current-voltage characteristic of semiconductor
power devices is analyzed, taking into account consequences of high current
density (10 A/cm^2 to 30 kA/cm^2) at which modern devices operate. Non-
linear electron-hole scattering and nonlinear and nonlinear recombination
of moving injected charge carriers are accompanied by a lower injection
efficiency of emitter p-n junctions and a narrower forbidden band of
heavily doped layers. In devices produced by diffusion technology, moreover,
the smooth distribution of impurity over the diffusion layer facilitates
compensation of the potential barrier and subsequent injection of the
neutral electron-hole plasma into that layer. This, and structural non-
uniformity of electrophysical properties, are additional factors influencing
the forward branch of the current-voltage characteristic. The analysis
is based on the equation of diffusion for the phenomenological model, with
the recombination rate depending on the Auger constants $C_n + C_p$ and on the
Schottky-Reed lifetime statistics $\tau_{n0} + \tau_{p0}$. It is solved here for diodes
with p^+nn^+-structure and high injection level $p \approx n \gg N_d$ (N_d- donor concentra-
tion in n-base). Calculations, supported by experimental data, reveal that
the voltage drop across the base layer depends largely on the ratio τ_b/τ_e
(lifetimes of injected charge carriers in base and in emitter, respectively),
this ratio being largely determined by the technology. The calculations
also reveal that the ratio W/L of effective base width to effective diffu-
sion distance in it depends on the current flowing through the structure.
The results indicate that at high current densities it is Auger recombina-
tion rather than electron-hole scattering which determines how linear the
forward current-voltage characteristic of devices with wide-base structure
will be. Figures 2; references 23: 13 Russian, 10 Western.
[235-2415]

ALLOWABLE SURGE CURRENTS AND FAILURE MECHANISMS IN SEMICONDUCTOR POWER
DEVICES IN VARIOUS MODES OF OPERATION

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[Abstract] Because the allowable surge current in a semiconductor power
device is determined by heating, it must be related to the allowable
temperature and the latter must be calculated first. This is done for
devices with pressure contacts on the basis of the corresponding system
of two differential equations of transient heat conduction, one for the
silicon crystal and one for the metal components. The thermophysical
properties of all materials, except silicon, are assumed to remain constant.
The initial temperature is assumed to be the same for all components and to
remain the same at the free boundary surfaces. The thermal characteristics
of a pressure contact, assumed to be ideal at soldered joints, are represented
by a resistance which when multiplied by the thermal flux yields the tempera-
ture jump at that contact. Energy is assumed to evolve uniformly over the
entire silicon structure. The voltage as a function of time t and temperature
T is described by the semiempirical relation $V(t,T) \simeq V_0 + i(t)R_{d,0}(1+\alpha\Delta T)$ with
$\Delta T = T - 300$ K (T- mean absolute temperature of silicon structure; R_d- dynamic
resistance) and with the temperature coefficient α corresponding to currents
higher than the current at which the temperature coefficient of voltage
reverses sign. Calculations have been made by this method for T-630
thyristors with pellet construction and pressure contacts. Such contacts
are found to strongly inhibit heating under a half-sine current surge.
Conditional failure of thyristors such as spurious switching because of one
or several parameters temporarily exceeding allowable limits as a result of
a temperature rise is evaluated on this basis. Failure caused by the surge
current following application of a reverse voltage is evaluated from the
standpoint of the breakdown mechanism. Failure caused by a forward surge
current in high-injection devices such as p-i-n diodes is evaluated from the
standpoint of the current filamentation mechanism and resulting perforation
of the structure by melting. Figures 2; tables 2; references 10: 6 Russian,
4 Western.
[235-2415]

SEMICONDUCTOR SUBMICROSECOND POWER COMMUTATOR SWITCHES

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[Abstract] Existing pulse thyristors are capable of commutating currents up to 100 A under a voltage of 1 kV. Increasing the capacity of such thyristors to 1 MW of pulse power at a pulse rise time of 100 ns or shorter involves either decreasing the load resistance, although below 1 ohm the switching time increases excessively because of the finite parasitic circuit inductance, or increasing the initial applied voltage. In the latter case maximum switching speed is attained by preventing localization of the current during the turn-on transient period. Localization is caused by appearance of an incipient turn-on region during the initial slow turn-on stage, and results from a subsequent fast change from uniform to highly nonuniform current distribution in that region upon transition from the initial slow turn-on stage to the final fast turn-on stage of the transient process. Current equalization follows the transient, but is completed only after a time much longer than the transient period. There are two necessary conditions for higher current capacity. One is widening the structure area active during the transient to the n-emitter dimension, but this does not suffice. It would be preferable altogether to eliminate formation of the incipient turn-on region. The second necessary condition, preventing "dynamic current localization during the fast turn-on stage, and the structural nonuniformity of electrophysical properties determine the minimum width $W_n + W_p$ of both base layers and thus the current density, on which the switching speed depends in addition to depending on the voltage. It is, accordingly, necessary to provide control action which will ensure a higher than critical density of the anode current at the beginning of the turn-on transient. Paradoxically, dynamic current localization is less appreciable when the circuit inductance limits the switching speed. Turn-on by a laser power pulse, without use of the control electrode, is difficult and requires intricate equipment. Turn-on by a momentary overvoltage (in the statistical sense) pulse is preferable. In this case impact ionization and the conductive component of the current provide the necessary action, while the capacitive current component is ineffective. Experiments have confirmed that combining such an overvoltage pulse with suppression of dynamic current localization can raise the current capacity of submicrosecond switching thyristor series chains by at least two orders of magnitude. Figures 4; references 11: 9 Russian, 2 Western.
[235-2415]

TWO-ROTOR ALTERNATORS WITH SUPERCONDUCTOR FIELD WINDING

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[Abstract] A two-rotor construction has been proposed for synchronous a.c.
m chines with superconductor field windings, as a means of physically
separating hot components from cold components and thus minimizing the heat
leakage to the cold component with a resulting more efficient cryogenic
cooling of the latter. The two rotors are mounted on the common shaft,
coaxially in separate bearings. The two-rotor concept dates back to
M. Corsepius (1903) and F. Punga (1926). Superconductor field windings
are favored by American and French engineers for synchronous generators and
motors. There are two possible configurations: 1) Hot working rotor with
shorted winding or field winding and freely running cold rotor with super-
conductor field winding; and 2) Cold working rotor with superconductor
field winding and freely running hot rotor, usually in the form of a hollow
conducting cylinder. The first configuration is preferable on account of
better minimizability of heat leakage, but the hollow-rotor construction
offers advantages. Calculations show that the two-rotor construction is
not economical for low running speeds. Calculations also show that a two-
rotor alternator with two field windings, a hot outer one running driven by
the turbine and a freely running inner one with superconductor coils, has
worse underexcitation and short-circuit characteristics than a single-
rotor machine with superconductor field winding. The pull-in characteristics
and the torsion on the shaft during transients depend largely on the moments
of inertia of the rotors. To this must be added the effect of the shield,
which in the steady state behaves like a squirrel cage of an induction motor
running with a slip. The shield can be accelerated with the armature
(stator) winding open and the cold rotor running at synchronous speed while
direct current is fed to the field winding or with the armature (stator)
winding open and the cold rotor accelerated by the turbine to synchronous
speed. Both methods are comparatively evaluated here for starting and running
performance. The results indicate a need for further analysis and refinement
of the hollow-rotor construction as well as thermal and mechanical effects
of anomalous transients, also for a study of the behavior of such a machine
as a part of a large power system. No such study has yet been made. It
will then be necessary and possible to optimize the starting performance of
such a two-rotor machine. Figures 2; references 18: 6 Russian, 2 Western
(1 in Russian translation).
[235-2415]

INSTRUMENTATION AND MEASUREMENTS

AUTOMATIC CORRECTION OF STATIC CHARACTERISTIC OF MEASUREMENT CHANNEL OF
DIGITAL OSCILLOGRAPH

[Article by A. M. Berkutov and Yu. D. Matyukhin, Ryazan Institute of Radio
Engineering]

[Text]   The measurement channel of a digital oscillograph
is examined and a method is proposed for correcting its
static characteristic. As a mathematical model of the
static characteristic it is proposed to use a piecewise-
polynomial interpolant based on a Newton polynomial and a
three-point cubic spline. The definition of the three-
point cubic spline and a formula for the residual member
(without derivation) are given. An example is cited in
order to illustrate the effectiveness of the correction.

The measurement channel (MC) of a digital oscillograph (DO) [1] usually
contains an input device which biases and normalizes the signal being in-
vestigated to values suitable for conversion in an analog-to-digital con-
verter (ADC), an ADC and an operational memory unit which serves to store
the bulk of the instantaneous digital readings coming from the ADC. The
static conversion function (SCF) of the represented channel should have a
high stability and linearity over a wide range of conversion, which is
determined by the specific of the visual perception and the quick-analysis of
the form of the signals from the oscillograph screen.

The characteristics required in digital oscillography are relatively easily
achieved through the introduction of automatic correction (AC) of the SCF,
because information in the DO is represented in the form of digital codes,
while one of the basic devices of the element base is a microprocessor, which
naturally realizes the hardware needed for correction.

The most widely used methods of automatic correction are the sample-signal
method [2], the iteration method [3] and the test method. The investigations
made by the authors [4] have shown that as applied to digital oscillography .
the best results are obtained by the first method with subsequent inclusion
of a corrector.

The essential features of the method are shown by the structural diagram (see Figure). The measurement channel is supplemented by a series-connected correcting device (CD), with a device for controlling the parameters $b \in B$ of the static conversion function. The control unit (CU) determines
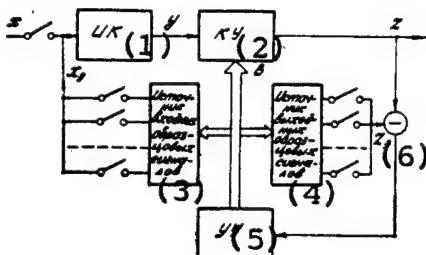
Fig. 1. Structural diagram of the autocorrected measurement channel of a digital oscillograph

Key:
1. MC
2. CD
3. source of input sample signals
4. source of input sample signals
5. CU
6. $Z_{\ni}$

the vector F_c of the parameters of the conversion function of the correction device, on the basis of an analysis of the deviation of the corrected SCF $F_c: x_e \to Z$ from the nominal $F_n: x \to Z_{\ni}$. As a result of adjustment of F_c the values of Z approximate $Z_{\ni}$ with a given exactness.

The mathematical model of a broad class of real SCF F_r of the measurement channel of a digital oscillograph is described by a polynomial of the mth degree with ℓ members. In the general case the nominal SCF F_n may be represented by a polynomial of the $m*^{th}$ degree. The number of pairs of standards $(x_{\ni}, Z_{\ni})S$ will be determined by the values of m and m*. Usually $S \geq m + 1$ if m>m*, and $S \geq m* + 1$ if m<m*.

In the solution of the majority of measurement problems the nominal SCF of the measurement channel of a DO should be a straight line passing through the corrdinate origin, while the number of pairs of standards S of the model is determined by the degree of the polynomial M. It is necessary to assume that in the correction process the approximating function of the corrector F_c passes through the interpolation nodes and is smooth.

As a function of this type we will use piecewise-polynomial interpolants, which permit separable adjustment of coefficients and have good interpolating properties. We will investigate the possibilities of the Newton interpolation formula and of the cubic spline.

We will write the Newton interpolation formula for nonequivalent values of the argument in the following form:

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$$Z(y) = \sum_{j=0}^{k} b_j f_j(y), \qquad (1)$$

where

$$
\begin{aligned}
f_0(y) &= 1, \\
f_1(y) &= (y - y_0), \\
f_2(y) &= (y - y_0)(y - y_1), \\
&\cdot \quad \cdot \quad \cdot \quad \cdot \quad \cdot \quad \cdot \quad \cdot \quad \cdot \quad \cdot \\
f_K(y) &= (y - y_0)(y - y_1) \ldots (y - y_{k-1}), \quad S = m+1 = k+1.
\end{aligned} \qquad (2)
$$

In the interpolation problem the Newton polynomial generates the discrepancy function

$$\Delta = \delta(B) = Z_i - Z_{ei}, \qquad (3)$$

the coefficients $b \in B$ being determined through computation of the various orders of finite differences. In the given variant it is proposed to determine the coefficients $b \in B$ with the aid of an iteration procedure according to the following recurrence formula:

$$b_j[n+1] = b_j[n] + \Delta_j[n]\bar{\mu}_j, \qquad (4)$$

where $n = 1, 2, 3, \ldots$ is the number of the iteration and μ_j is the weighting coefficient.

By feeding the values of the sample signals $(x_{\ni 0}, x_{\ni 1}, \ldots, x_{\ni m})$ to the input of the conversion channel, we obtain the values of the interpolation nodes $(y_0, y_1, \ldots, y_m)$ at the corrector input. After storing these signals we can proceed to the procedure of adjusting the coefficients in accordance with formula (4), taking into account the Newton expansion property of (1) and (2). It is necessary to begin the adjustment from coefficient b_0 and adjust b_1, b_2 etc. in strict order. The adjustment has the characteristic feature that if $y = y_0$ is fed to the corrector, all f_i (except f_0) go to zero, while the output coordinate of the corrector will be determined by the coefficient of polynomial (1). If the discrepancy function (3) is combined with coefficient b_0 in accordance with (4), the b_0 component of vector B is entirely separably determined. Then, taking this b_0 which has been fed to the input of corrector $y = y_1$ into account, it is possible to determine in an analogous manner the next component of vector B and so on until all of the components of the vector have been found. The criterion for stopping the vector component adjustment procedure will be the inequality $\delta(B_i) \leq |\varepsilon|$, where ε is the insensitivity zone of the comparison device.

A simple adjustment system results in which the expansion coefficients
are found from the following formulas:

$$
\left.
\begin{aligned}
b_0[n+1] &= b_0[n] + \Delta_0[n]\mu_0, \\
b_1[n+1] &= b_1[n] + \Delta_1[n]\mu_1, \\
\cdot\;\;\cdot\;\;\cdot\;\;\cdot\;\;\cdot\;\;\cdot\;\;&\cdot\;\;\cdot\;\;\cdot\;\;\cdot\;\;\cdot\;\;\cdot \\
b_k[n+1] &= b_k[n] + \Delta_k[n]\mu_k.
\end{aligned}
\right\}
\qquad (5)
$$

In its "pure" form, however, it is expedient to use the Newton formula for
the correction of weak nonlinearities. When there are strong nonlinearities
in the characteristic it is necessary to use piecewise-polynomial interpolation.

Let us assume that the SCF of the corrector is a function of the smoothness
class $C^{(p)}$. It is possible to construct a multinomial of degree not higher
than $2p + 1$ which satisfies the "junction" conditions at the nodes up to the
p^{th} derivative inclusively [4]. Let us limit ourselves to the case of $p = 1$.
Let $y_0 < y_1 < y_2 < \ldots < y_\ell$, a grid in the nodes of which the values of the function
$Z_{\ni 0}$, $Z_{\ni 1}$, $Z_{\ni 2}$, ..., $Z_{\ni \ell}$ are known. In the section (y_0, y_1) let us introduce
the multinomial of degree $2p + 1 = 3$ described by the Newton formula (1) and
(2).

Let us assume that the coefficients b_j have been determined. Let us con-
struct an interpolation function in the segment (y_1, y_2) also in accordance
with formula (1) and (2), taking point y_1 as the reference origin, and so on
up to the interval $(y_{\ell-p-1}, y_{\ell-p})$. The constructed interpolant $F_c(y)$ is a
piecewise-polynomial function of smoothness class $C^{(p)}$; the degree of the
polynomials in the intervals of the grid is $2p + 1$. Because the interpolant
in question generates in the interpolation segments a discrepancy function
which is linear in its parameters, it follows that the coefficients for each
interpolant, as before, may be determined with the aid of procedure (5).

In spite of all of the advantages of the interpolant considered here it has
a significant shortcoming: it gives rise to a large dimensionality in ad-
justment vector B. Thus at $S = 7$ the number of components in B is 15. Let
us therefore consider the following interpolant (a three-point cubic spline),
which is free of this shortcoming.

Let us first consider a cubic spline of the following type. Let there be,
in segment $[a, b] = R_{Fp}$, where R_{Fp} is the range of the corrector input
signal, a grid $a = y_0 < y_1 < \ldots < y_n = b$, at the nodes of which the values of the
function (generated by the NSFP model) $Z_{\ni 0}$, $Z_{\ni 1}$, ..., $Z_{\ni n}$ are known.

Let us represent the SCF of the corrector in the form of a cubic spline the
expression for which has the form

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$$g(y) = b_{i-1} \frac{(y_i - y)^3}{6h_i} - b_i \frac{(y - y_{i-1})^3}{6h_i} +$$
$$+ \left(Z_{i-1} - \frac{b_{i-1} h_i^2}{6} \right) \frac{y_i - y}{h_i} + \left(Z_i - \frac{b_i h_i^2}{6} \right) \frac{y - y_{i-1}}{h_i}, \tag{6}$$

where $h_i = y_i - y_{i-1}$ $(i = 1, \ldots, n)$.

An interpolant of type (6) belongs to the class $C^{(2)}(a, b)$; at each of the segments $[y_{k-1}, y_k]$ it appears as a cubic multinomial; at the grid nodes $\{y_k\}_{k=0}$ equalities $g(y_k) = Z_k$ $(k = 0, 1, \ldots, n)$ are satisfied; the second derivative of $g(y)$ satisfies the boundary condition

$$g''(a) = g''(b) = 0, \tag{7}$$

the coefficients b_1, $b_2, \ldots,$ b_{n-1} are found from the system of linear algebraic equations [5]:

$$Ab = HZ. \tag{8}$$

The solution of a system of linear algebraic equations leads only to explicit adjustment methods, and the adjustment time of the coefficients increases significantly.

Let us consider a three-point cubic spline. Let us introduce the following interpolant. In segment [a, b] of real axis y let two sets of nodes be given:

$$\Delta_n : a = y_0 < y_1 < \ldots < y_n = b \quad (9); \quad \Delta_n : \bar{y}_0 = a < \bar{y}_1 < \ldots < y_n < \bar{y}_{n+1} = b \tag{10}$$

We will assume that

$$y_{i-1} < \bar{y}_i < y_{i+1} \quad (i = 1, \ldots, n). \tag{11}$$

Definition 1. A function $g(y)$ is termed a cubic three-point interpolation spline for function $Z(y)$ if $g(y)$ is defined by expression (6), belongs to class $C^{(2)}(a, b)$, it is a cubic multinomial at each of its segments $[y_{k-1}, y_k]$, at the nodes of grid (9) the equality $g(y_k) = Z_k$ $(k = 0, 1, \ldots, n)$ is satisfied, and at the nodes of grid (10) the equality $g(\bar{y}_\ell) = Z_\ell$ $(\ell = 0, 1, \ldots, n + 1)$ is satisfied. The coefficients $b_1, \ldots, b_i, \ldots, b_n$ are found from the expression

$$b_i = \frac{\bar{Z}_i - b_{i-1}(y_i - \bar{y}_i)^3/6h_i - Z_{i-1}(y_i - \bar{y}_i)h_i^{-1} + b_{i-1}h_i(y_i - \bar{y}_i)/6 - Z_i(\bar{y}_i - y_{i-1})h_i^{-1}}{(\bar{y}_i - y_{i-1})^3/6h_i - h_i(\bar{y}_i - y_{i-1})/6}, \tag{12}$$

with $b_0 = 0$.

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In contrast to the cubic spline, the coefficients of which are found from a system of linear algebraic equations (8), in the spline in question here the coefficients b_i are determined both from formula (12) and by the adjusted model of algorithm (4). This makes the interpolant in question preferable to the classical interpolant. The adjustment of the coefficients is carried out strictly in sequence, beginning with b_i.

The order of approximation of the interpolant for the case
$$\overline{y}_i = \frac{y_{i-1} + y_i}{2}$$
is evaluated by means of the residual member $|R(y)| = |Z(y) - g(y)| \leq |Z''(\xi_i)|\,||\Delta_n||^2$, $y \in [a, b]$.

The majority of RSCF of measurement channels are described by polynomials of the first, second and third degrees. For example, $y = \alpha_0 + \alpha_1 x + \alpha_2 x^2 + \alpha_3 x^3$, but the nominal static function of the converter will be the bissector of the coordinate angle $Z = x$. The quality of the correction may be evaluated from the relation

$$V = \frac{\int_{DF_p} |F_r - F_n|\,dx}{\int_{DF_p} |F_s - F_n|\,dx},$$

where F_{co} is the real static conversion function of the corrected MC and DF_p is the domain of values of F_p.

As an example let us examine the correction of the RSCF of the measurement channel of a DO designed to record single signals. The measurement channel consists of an attenuator, a logarithmic amplifier and a high-speed eight-place analog-to-digital converter. A characteristic feature of the operation of a DO of this sort is the fact that after being switched on it can be in the signal expectation mode for a long time (several hours). In this regard, in the DO in question correction of the RSCF is carried out after recording of the last sample of the signal being investigated. WWith the aid of a commutator the input of the channel is fed seven levels of sample voltages. The results of the conversions of the sample voltages are registered in the working memory unit. A microprocessor (realized, using LIC of the 589 series) realizes the adjustment of the coefficients of the static conversion function of the correcting device [in accordance with formula (12)]. A three-point cubic spline is used as the mathematical model of the SCF of the correcting device. After all of the coefficients have been determined, the results of the conversion are extracted from memory and processed by the processor in accordance with expression (6). The results of the processing are represented on the master screen of the DO using a linear scale with an error of not more than 0.5%.

The above-described approach to the solution of the problem of the automatic correction of the static conversion function of the measurement channel of

a digital oscillograph permitted elimination of the manual adjustment
procedure and linearization of the static characteristic, while preserving
a quasi-uniform relative error and a broad conversion range.

BIBLIOGRAPHY

1. The OTsR-5 Digital Oscillograph, BERKUTOV A. M., VIKHROV G. P.,
    VOLKOV V. V., GIRIVENKO I. P. and PROSHIN E. M., TEKHNIKA SREDSTV
    SVYAZI, .RT Series, No. 3, 1976, pp 129-135.

2. ZEMEL'MAN M. A., "Avtomaticheskaya korrektsiya izmeritel'nykh ustroystv,"
    [Automatic Correction of Measurement Devices], Moscow; Sandarty, 1972,
    200 pages, illustrated.

3. ALIYEV G. M. and SEYDEL' A. R., "Avtomaticheskaya korrektsiya
    pogreshnostey tsifrovykh izmeritel'nykh priborov," [Automatic
    Correction of Error in Digital Measurement Instruments], Moscow:
    Energiya, 1975, 216 pages, illustrated.

4. BERKUTOV A. M., MATYUKHIN Yu. D. and POVARENKIN N. N., "Morphological
    Analysis of Automatic Correction Methods," IZMERITEL'NAYA TEKHNIKA,
    No. 12, 1982.

5. MARCHUK G. I., "Metody vychislitel'noy matematiki," [Methods of Computer
    Mathematics], Moscow: Nauka, 1977, 456 pages, illustrated.

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INITIAL FOCUSING DISPLACEMENT INTERVAL IN DETERMINING REQUIREMENTS ON
MICROSCOPE FINE-FOCUS MECHANISM

[Article by I. V. Knoroz, Leningrad Institute of Precision Mechanics and
Optics]

> [Text] The magnitude of the interval of focusing displacements
> recommended as basic in setting the requirements on the fine-
> focus mechanism of a microscope is determined.

Currently the magnitude of the transverse image shift caused by error in
the fine-focus mechanism (FFM) are attributed to the overall range of the
FFM displacement (~2 mm), which gives rise to significant difficulties in
the mass production of microscopes. Moreover, transverse image shifts can
be noted only in a certain significantly smaller interval of focusing dis-
placements, which we will call the basic focusing interval (BFI), and for
which the magnitude of the transverse shift caused by the FFM should be
normalized.

The purpose of the present effort is to evaluate the magnitude of the BFI,
inasmuch as there are as yet no recommended magnitudes for it [1].

The focusing process, from the point of view of its main function, i.e.,
to guarantee detailed examination of the object of observation*, proceeds
differently in microscopes with a nose-piece and in those without it (both
are widely used).

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*The use of FFM in microscopes for certain specialized measurements (e.g.,
coordinate measurements in nuclear microscopes et al.), which pose
especially strict image shift requirements based on considerations different
from those formulated at the beginning of the article, requires a different
approach to the evaluation of the interval N, proceeding from the operating
distance of the microobjects used.

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In the absence of a revolving nosepiece, the operator, working directly with the rough-focusing mechanism with a strong objective, begins to approximate the objective point P of the objective to the object element O (Fig. 1). [Graphics not reproduced.] (Whether the tubule with the objective or the stage with the object moves is unimportant.)

At a certain position O_1 of the objective point of the objective the observer begins to see an image, still vague, of the object element (the boundary of uneven illumination of the field). From this moment further focusing is realized by the FFM, because it provides smaller threshold displacements [2]. As the object element approaches the objective point of the objective, the definition of the image increases and remains equally good within the limits of a certain zone T_1T_2, called the definition depth zone for a given combination of objective and eyepiece. When the objective point of the objective passes through the second boundary T_2 of the definition depth zone the image again worsens and as a result of its lack of definition begins to lose resemblance to the object element at level O_2. During actual focusing settings the entire zone O_1O_2 is not used. It is sufficient for the observer to move the objective point of the objective a certain small distance ε across boundary T_2 in order to sense a decrease in image definition, which induces him to return to the definition depth zone T_1T_2. Thus, in practice the distance from the "signal" plane corresponding to the above-described position O_1 of the objective point to the second boundary of the definition depth determines N, the magnitude of the BFI during operation without a nose-piece:

$$N = O_1T_1 + T_2T_2 + \varepsilon. \tag{1}$$

Inasmuch as computation of the magnitude of N is difficult, its greatest value was found experimentally, which required clarification of the dependence of N on the contrast of the objects, and the magnifications and apertures of the objectives used.

The magnitude of N in question was measured on the FFM scale of the microscope during its focusing to the definition of the image of the object without use of a nose-piece. In emergent (prokhodyashchiy) light under normal illumination three objects with various contrasts were examined—a facsimile preparation to check the quality of the objectives, a biological stained preparation from a standard collection and an object-micrometer. Each of the objects was examined with three achromatic objectives: 20 x 0.4, 40 x 0.65 and 60 x 0.85, and a 7^X Huygens eyepiece. During the measurements the rough feed mechanism was used to focus up to an indefinite image of some element of the object, and in this position a reading was taken from the FFM cylinder. Then the FFM was used to focus up to a definite image and the second definition depth boundary was passed to a magnitude permitting detection of a decrease in definition, which corresponds to the second reading from the FFM cylinder. Each of the measurements for fixed conditions was performed 10 times. Measurements of a single type were performed by three different operators. Statistical analysis of the measured values showed that variation in the data obtained by different observers was random. The following were determined: the nonlinear negative correlation association

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(correlation ratio $\eta = 0.90$) between the characteristics of the objectives and $\bar{N}$, and the nonlinear positive correlation association (correlation ratio $\eta = 0.88$) between the object contrast and $\bar{N}$. The table [graphics not reproduced] of the statistical parameters of the BFI shows the average arithmetic values of $\bar{N}$ and the averate quadratic deviations of a number of measurements of σ (in micrometers) for the magnitude of N as a function of the object contrast, the magnification and aperture of the objectives.

The object contrast was determined from the formula $K = \dfrac{\tau_{max} - \tau_{min}}{\tau_{max} - \tau_{min}}$, τ

where τ_{max} and τ_{min} are the maximum and minimum values, respectively, of the transmission coefficients. Measurement of contrast was conducted using the KMM-L1 and MF-2 microphotometers. It is clear from the table that the maximum value of N was obtained for 20 x 0.4 objective and the facsimile preparation. Assuming that the boundary deviation for N is equal to 3σ, we obtain a numerical value of the maximum magnitude of the focusing interval of N = 130 μm.

The process of focusing with a nose-piece consists of two stages. The goal of the first stage is to select an element on the object for detailed investigation by means of strong objectives. The rough-focusing mechanism is used to achieve a sharp image of the object with a weak objective introduced into the path of the light beam, which corresponds to the position of the objective point P_1 of the objective at some random point of the definition depth zone of the space of the object for a combination of the eyepiece and a weak objective $T_{1B}T_{2B}$ (Fig. 2) [graphics not reproduced]. Then the nose-piece is rotated to introduce a strong objective into the light beam of the microscope. The second stage of the focusing is performed using the FFM and consists in obtaining a sharp image of the selected element of the object through a strong objective, which corresponds to finding the object point of the objective P_2 at some random point in the definition depth zone of the space of the object for a combination of the same eyepiece and a strong objective, $T_{1M}T_{2M}$. Consequently, the maximum difference between the two probable positions of the object point of the objective after the first stage and during the second stage, respectively, of the focusing (taking into account the allowable error of the heights of the objectives Δ) determines the focusing displacement interval for the FFM within the boundaries of which the observer perceives the nascent transverse image shifts. From the above-described method of operating the microscope using a nose-piece it follows that in this instance the interval N does not depend on the contrast of the object, and should be less than is the case without the nose-piece, and is determined only by the characteristics of the objectives and eyepieces. Therefore in working with a nose-piece it is easy to obtain an evaluation of the magnitude of N by the computational method. Computation for the case of a Huygens 7^x eyepiece and 8 x 0.2 and 20 x 0.4 objectives yields a maximum magnitude of N of 90 μm.

For a prescribed magnitude of the BFI within the boundaries of which it is expedient to adjust the transverse image shifts caused by error in the FFM, the largest of the evaluations obtained should be increased to 0.2 mm in order to preserve the accuracy characteristics during the entire period of use of the microscope.

Because the entire FFM displacement range (independent of its magnitude) can be regarded as a set of BFI, it is recommended that the operational characteristics of microscope FFM be checked for each of the segments of their operating range within the boundaries of the BFI.

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BIBLIOGRAPHY

1. GOST 8284-78, GOST 5.176-73, GOST 5.396-70 and GOST 5.397-70.

2. KNOROZ, I.V., "The Displacement Threshold as a Characteristic of the Operational Quality of the Mechanisms of Optical Instruments," IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: PRIBOROSTROYENIYE, No. 9, 1980, p 80.

A NOISE-SUPPRESSING DIGITAL FREQUENCY METER

[Article by V. S. Gutnikov and A. I. Bukhman, Kalinin Polytechnical Institute,
Leningrad]

[Text] The structure and properties are considered of a
digital frequency meter, which reproduces in the measurement
process a special graduated weighting function with whole-
number coefficients. This suppresses the additive noise
present in the input signal of the frequency sensor connected
to the input of the frequency meter.

In the design of digital instruments for the measurement of various physical
quantities the method of intermediate frequency conversion is widely used [1].
This method is currently being developed further in connection with the mass
production of inexpensive and efficient integrated voltage-to-frequency
converters (VFC) [2, 3].

As is well known, the advantage of integrated analog-to-digital converters
(ADC), to which category ADC with intermediate frequency conversion also
belong, is their low sensitivity to additive periodic noise present in the
input signal. A high level of noise suppression is achieved through the
realization in integrated measurement devices of a special weighting function
(WF). In ADC with intermediate frequency conversion the weighting function
may be reproduced by placing at the frequency meter input a frequency divider
with an adjustable dividing coefficient [4]. Specifically, in a device
consisting of a VFC and a digital frequency meter, in order to decrease
random error from line noise (present in the VFC input signal) it is
possible to reproduce a graduated WF with weighting coefficients of 1-2-1
or 1-3-3-1 and with a duration of each gradation equal to half of the
nominal period of the noise. In this case it is necessary to insert at the
frequency meter output a frequency divider the dividing coefficient of which
can be switched in sequence to the values 2-1-2 or 3-1-1-3.

Line noise is characterized by a bright-line spectrum. For this reason
binomial WF are used to suppress it, representatives of which are the above-
mentioned 1-2-1 and 1-3-3-1 WF. It is, moreover, frequently necessary to

suppress noise, the power of which is concentrated in some continuous frequency band. This type particularly includes noise caused by mechanical oscillation of the object being investigated, strong radio pulse noise etc.

The suppression of continuous-spectrum noise is guaranteed in a measurement device possessing the dynamic properties of a high-quality low-frequency filter. With a limited measurement time and a prescribed lower boundary of the noise frequency band, the minimum of the maximum level of the noise transmission coefficient is provided by a Dolf-Chebyshev weighting function [5]. The weighting coefficients of this WF are determined with the aid of a reciprocal discrete Fourier transformation from readings of the frequency characteristic described using a Chebyshev polynomial.

The error which cannot be exceeded in setting the weighting coefficients of the Dolf-Chebyshev WF may be determined approximately as the reciprocal of the expected noise suppression coefficient [4]. If, for example, it is planned to provide a noise suppression coefficient of 1000 (i.e. 60 dB), then the weighting coefficients should be determined and realized with an accuracy not less than 0.1%, i.e. with an accuracy up to the third significant decimal place.

The need to multiply the input frequency by the weighting coefficients determined by the three-place decimal numbers can significantly complicate the hardware of a noise-suppressing digital frequency meter.

The authors posed and solved the problem of finding whole-number low-place weighting coefficients which yield WF which have properties similar to Dolf-Chebyshev WF. This problem was solved in the following manner: First values were determined for the weighting coefficients of a Dolf-Chebyshev WF consisting of 16 readings and yielding a noise suppression coefficient of 65 dB. Then all of these values were multiplied by a scaling coefficient such that the minimum weighting coefficient approximately equalled one. Next all of the weighting coefficients were rounded off to whole numbers and the minimum value of the noise suppression coefficient obtainable in this way was determined. By means of computer sorting of the variants, a WF was found which was characterized by a minimum value of the noise suppression coefficient equal to 1.179×10^3 (61.4 dB) in a frequency band from $0.19f_1$ to $0.85f_1$ (or 59.1 dB in the band from $0.16f_1$ to $0.85f_1$), where $f_1 = 1/T_1$ is the pulse sequence frequency of the WF. The form of this WF and the amplitude-frequency characteristic (AFC) corresponding to it are shown in Fig. 1. In the same figure, an AFC corresponding to the Dolf-Chebyshev WF is shown for comparison with the dashed line. It is evident that the computed WF with whole-number coefficients guarantees noise suppression only 4 dB worse than the optimum Dolf-Chebyshev WF.
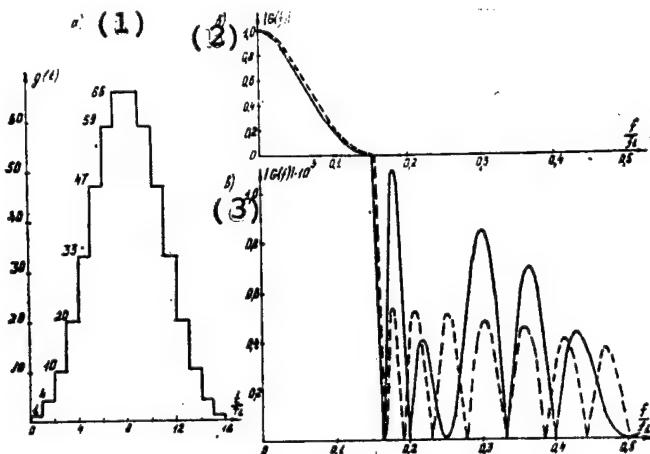
Fig. 1.   A graduated weighting function with whole-number
coefficients (a) and the amplitude-frequency
characteristic corresponding to it (b, c). The
scale of the vertical axis of (c) is 1000 times
that of (b).

Key:
   1.   a)   2.   b)   3.   c)

The computed WF was used to design a specialized digital frequency meter
intended to be used with frequency converters of physical quantities. A
simplified structural diagram of this frequency meter is given in Fig. 2.
In addition to the traditional units such as a control unit (CU), a
reference frequency generator (RFG), a divider of this frequency (D), a
counter (C) and a display device (DD), the frequency meter is question
also contains new units: a binary multiplier (BM) and a fixed memory unit
(FMU). As is evident from Fig. 2,
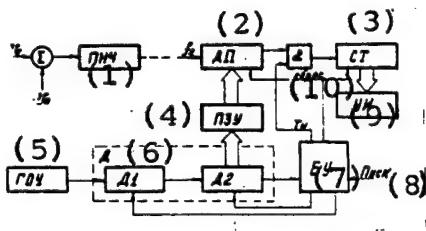
Fig. 2.   Structural diagram of a noise-suppressing
frequency meter connected to the output of
a voltage-to-frequency converter.

Key:
   1.   VFC   3.   C   5.   RFG   7.   CU   9.   reset
   2.   BM   4.   FMU   6.   D   8.   start   10.

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the reference frequency divider D is composed of two parts: dividers D1 and D2. Divider D2, with a scaling coefficient equal to 16, fulfills the function of a counter of the sections of the WF. A four-place binary code, obtainable from this divider, is used to control the FMU, in which is stored information on the values of the weighting coefficients (16 seven-place words). The FMU is realized using one 155RE3 microcircuit. The binary multiplier BM multiplies the measured frequency f_x by the weighting coefficients. It is composed of two 155IE8 microcircuits. The functioning of the frequency in question does not differ practically from that of traditional digital frequency meters. After the "Start" command arrives, the control unit CU generates the initial setting of the counter C and the binary multiplier BM. Then, during one measurement interval T_i the number of pulses passing through the binary multiplier BM and the AND logic unit is counted. The variable code fed from D2 to the FMU sequentially switches the values of the weighting coefficients, such that in the course of one interval T_i all 16 grades of the WF are realized.

The frequency meter was investigated experimentally by feeding pulses from an integrated voltage-to-frequency converter VFC to the input of the meter. The VFC input was fed a DC input voltage U_x and a harmonic signal U_n which imitates noise (Fig. 2). The amplitude of the noise U_n was set somewhat below voltage U_x so that the total VFC input signal would be monopolar.

The experimental coefficient of noise suppression was determined from the formula $K_p = \Delta \tilde{U}_{in}/\overline{U}_{in}/(\Delta \tilde{N}_y/\overline{N}_y)$, where $\Delta \tilde{U}_{in}$ and $\overline{U}_{in}$ are the mean-square deviation and the average value of the VFC input signal (in our case clearly $\Delta \tilde{U}_{in} = U_p$ and $\overline{U}_{in} = U_x$), and $\Delta \tilde{N}_y$ and $\overline{N}_y$ are the mean-square deviation and the average value of the output code of the frequency meter. If it were necessary to find the value of the noise-suppression coefficient in decibels, it was then determined from the relation $L_n = 20 \lg K_p$.

The degree of noise suppression depends on the accuracy of the setting of the weighting coefficients. In this case the error γ_s has two components in the setting of the weighting coefficients. The first component is determined by the quantization error in the shaping of the number of pulses arriving at the BM input during realization of one grade of the WF. The second component is the error caused by imperfect multiplication of the input frequency by the weighting coefficient in the binary multiplier (as is well known, the pulses at the BM output are unevenly distributed and the prescribed conversion coefficient is realized only with regard to the average value of the output frequency).

The experimental investigations showed that, in an approximate evaluation of the setting error, it is possible to take into account only the first component of the quantization error, i.e. it is possible to take $\gamma_s \approx 1/N_1$, where N_1 is the average number of pulses arriving at the BM in the course of one quantization grade. To find N_1 it is possible to use the relation $N_1 = (f_x T_i)/n$, where f_x is the average frequency at the VFC output and $n = 16$, the number of WF grades.

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Simultaneous consideration of imperfection in the WF (in the sense of non-infinite noise suppression) and imperfection in the setting of the weighting coefficients (definable by the error γ_s) leads to the following approximate formula:

$$K_n = \frac{K_{wf}}{\sqrt{1 + K_{wf}^2 \gamma_s^2}}, \qquad (1)$$

where K_{wf} is the coefficient of noise suppression which can be guaranteed by a given weighting function if it is realized precisely (in our case, as shown above $K_{wf} \approx 1.179 \times 10^3$).

Figure 3 shows the curve of the coefficient of noise suppression L_n as a function of the average number of pulses N_1 arriving at one degree of the WF. This curve was determined from formula (1) by substituting into it $\gamma_s = 1/N_1$. The experimental points of the function $L_n(N_1)$ are plotted on the same graph. We see that the results of the experiment agree well with the assumed model.
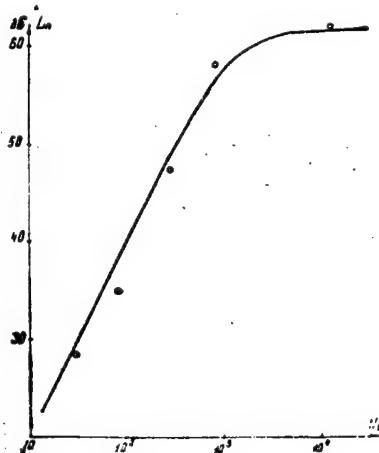
Fig. 3.

Thus, the addition of only three logic microcircuits to the traditional frequency meter circuit succeeded, in an ADC consisting of a VFC and a frequency meter, in guaranteeing a high (of the order of 60 dB) coefficient of suppression of broad-band noise.

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BIBLIOGRAPHY

1. NOVITSKIY P. V., KNORRING V. G. and GUTNIKOV V. S., "Tsifrovyye pribory s chastotnymi datchikami" [Digital Instruments with frequency meters], Leningrad, Energiya, 1970, 424 pages.

2. CHISTYAKOV N. P., "Sovremennyye mikroelektronnyye preobrazovateli napryazheniya v chastotu" [Modern Microelectronic Voltage-to-Frequency Converters], ZARUBEZHNAYA [Foreign] RADIOELEKTRONIKA, 1981, pp 100-106.

3. SUD'IN S. L., "Monolithic Voltage-to-Frequency and Frequency-to-Voltage Converters", in "Tsifrovaya informatsionno-izmeritel'naya tekhnika: Mezhvuz. sb. nauchn. tr., Vyp. 12" [Digital Information-Measurement Engineering: Interinstitutional Collection of Scientific Works, Vol. 12], Penza, Penza Polytechnical Institute, 1982, pp 61-68.

5. RABINER L. and GOULD B., "Teoriya i primeniniye tsifrovoy obrabotki signalov" [Theory and Application of Digital Signal Processing], Moscow, Mir [World], 1978, 848 pages.

COMPARATIVE CHECKING OF USSR AND CUBAN NATIONAL TIME AND FREQUENCY ETALONS
BY MEANS OF TRANSPORTABLE QUANTUM CLOCKS

PUSHKIN, S. B., SINENKO, L. A., NASIDZE, N. A. and IGLESIAS, S.

[Abstract] In accordance with the program of bilateral scientific-technical
cooperation between the Soviet Union and Cuba, a comparative checking of
their national time and frequency etalons was undertaken with the use of
transportable quantum clocks. Soviet and INIMET [Cuban?] Institute of
Scientific Information on Metrology) UTC time scales were compared, while
the metrological characteristics of INIMET quantum keepers were measured,
the INIMET scale synchronization channel through radio navigation systems
was calibrated, and fluctuations of the etalon-signal transmission time over
the Moscow-Havana satellite television channel were evaluated. The equip-
ment at the INIMET time and frequency laboratory, built with Soviet aid,
includes: devices for reproducing and keeping units of time and frequency
on the basis of 1969 rubidium standards; a system for hourly internal
comparative checking of second pulses with a $1:10^{-8}$ s resolution; receiving
comparators for frequency and time signals transmitted through radio stations,
with tying of the INIMET time scale to the UTC coordinated atomic time scale
and to the Soviet UTC time scale within 2 µs accuracy; a system for shaping
and transmitting etalon time and frequency signals over Cuban radio and
national television channels; and auxiliaries such as power supplies, signal
generators and frequency synthesizers. At the present time a radio channel
provides the main tie between Soviet and INIMET time scales, their comparative
checking being done with LORAN-C radio navigation signals. The rms random
error of this procedure was found to be smaller than 0.5 µs. Measurements
were made with the transportable quantum clock of the All-Union Scientific-
Research Institute of Physicotechnical and Radiotechnical Measurements
(VNIIFTRI). Figures 3; tables 2; references: 3 Russian.
[154-2415]

COMPARATIVE CHECKING OF CZECHOSLOVAK AND HUNGARIAN NATIONAL TIME SCALES WITH SOVIET UNIVERSAL TIME COORDINATED THROUGH WESTERN OUTPOST OF GOVERNMENT TIME AND FREQUENCY SERVICE

PINCHEVSKIY, A. D., PUSHKIN, S. B., DUDICH, I. I., KUKHARENKO, O. I., SEVAST'YANOVA, O. I. and GROKH, Yu.

[Abstract] Uzhgorod is the western outpost of the USSR Government Time and Frequency Service (GSVCh), for comparative checking of the Soviet UTC (Universal Time Coordinated) etalon with the International Time Bureau (MBV) in Paris over television broadcasting channels. In this outpost time and frequency keepers are located as well as transportable clocks with necessary maintenance and antenna-feeder equipment. This outpost is also used for comparative checking of Czechoslovak and Hungarian national time scales, their Universal Time Coordinations UTC (TP) and UTC (OMX), respectively. This is done over television broadcasting channels, with programs originating in Prague and in Budapest, as well as signals from the Moscow television center being received in Uzhgorod and there monitored for this purpose. The signal propagation time is measured with high-precision quantum clocks, comparative checking by this method being accurate within 0.1-0.5 µs. The equipment includes a hydrogen frequency and time standard, a cesium frequency standard, a rubidium frequency standard, and a time interval meter. Fundamentally unlike Soviet television channels, both Czechoslovak and Hungarian ones have no permanent phasing of synchronization signals at the broadcasting centers against appropriate etalons. Therefore, simultaneous readings must be taken at transmitting and receiving ends with a subsequent exchange of data. The network for comparative checking of time scales under these circumstances has a secondary time-frequency etalon (USSR) in Uzhgorod at the center, to which signals are fed from the Prague (Kosice) television center with the TP time-frequency etalon and from the Budapest television center with the OMX time-frequency etalon as well as from the Ostankin [Moscow?] television center with the Government (USSR) time-frequency etalon and a processing center. This processing center receives also information directly from Prague and Budapest, while it is engaged in two-way communication with both Government and secondary time-frequency etalons. The signal propagation time is measured semiannually, a statistical analysis of readings indicating that the measurement error does not exceed 0.02-0.5 µs. Use of a secondary time-frequency etalon has been found to play an important role in comparative checking of national time scales, especially when its frequency instability can be reduced to below $1 \cdot 10^{-13}$ (equivalent to a 10-300 ns error of independent time keeping over a period of 1-30 days). Figures 3.
[154-2415]

METHODS OF COMPARATIVE CHECKING OF CLOCKS THROUGH OPTICAL COMMUNICATION
CHANNEL

BYSOKOSOV, Ye. P., KLYUYEV, V. A. and YUNOSHEV, L. S.

[Abstract] At the present time transportable clocks provide the most
accurate means for comparative checking of remote time scales. Comparative
checking of clocks on board ships or aircraft against stationary ones is
most effectively done over optical communication channels. A semiconductor
laser such as a ruby laser is a suitable light source which facilitates
operation at a high rate of signal repeat with a high stability of signal
delay, but also requires either a special telemetering channel or synchroniza-
tion of the laser radiation with the time marker carrier on board. The
critical component of the difference between corrections for the on-board
clock and for the stationary clock is the delay of laser pulse emission
relative to the on-board time marker, this delay and its stability during
conversion of the electric signal to an optical one having been measured with
special equipment which includes a GaAs laser. The delay was found to vary
from device to device and thus not to be constant. Accordingly, precision
comparative clock checking, a scheme is proposed which includes synchroniza-
tion by means of a pulse laser and appropriate time delay control, measure-
ment of time intervals and photoelectric signal conversion. This scheme and
method of implementation have been evaluated in terms of accuracy, stability,
and other metrological characteristics as well as the design and performance
characteristics of critical electrical and optical components. Figures 3;
references 2: 1 Russian, 1 Western.
[154-2415]

CHARACTERISTICS OF ETALON FREQUENCY AND TIME SIGNALS TRANSMITTED OVER
SPECIAL-PURPOSE RADIO STATIONS

CHERENKOV, G. T.

[Abstract] All currently operating special-service low-frequency radio
stations for transmitting etalon frequency and time signals operate with
amplitude modulation of the carrier oscillation by square pulses, less than
100% modulation (25 or 33%). This results in better simultaneous transmis-
sion of frequency signals and time markers as well as digital data about
the state of various time scales. In this paper the characteristics of
etalon frequency and time signals transmitted over such systems are analyzed
in terms of power and information content indicators, the latter expressed
in the code format. The performance characteristics of two Soviet radio

stations RBU and RTZ are compared with those of WWVB (US), MSF (UK), and DCF-77 (FRG) in terms of three power parameters: $\alpha = P_c/P_{max}$, $\beta = P_M/P_{max}$, and $\gamma = (P_c + P_M)/P_{max} = \alpha + \beta$ (P_c - carrier power, P_M - power of modulated signal components, P_{max} - maximum power in continuous-transmission mode). The parameters of both Soviet radio stations are evaluated as averages over a 6 min period with the carrier modulated by time marker pulses and as averages over a 1 h period, the latter including 7 min of time marker and identification signal transmission and 53 min of unmodulated carrier transmission. Further calculations reveal that the interference guard band of simultaneously transmitted frequency signals, time markers, and digital data is not wider than 1 Hz for any radio station operating in this service. Figures 2; tables 2; references 6: 3 Russian, 3 Western.
[154-2415]

RADIO INTERFEROMETER DEVICES FOR MEASUREMENT OF EARTH'S ROTATION AND SYNCHRONIZATION OF TIME SCALES

ALEKSEYEV, V. A.

[Abstract] A very-long-base radio interferometer is considered as a means for performing a set of measurements in the space-time domain with cross-correlational processing of the data. One particular application of interest is measurement of the earth's rotation and the synchronization of time scales far removed from one another. Optimum selection of the operating wavelength, as a tradeoff accounting for characteristics of signal transmission through the atmospheric layers on the one hand and of radio emission from cosmic sources on the other hand, is followed by an interferometer design and performance analysis from the standpoint of optimization. A very-long-base interferometer structure for independent reception is proposed, namely two sets of antenna, high-frequency amplifier, mixer, analog-to-code converter, memory, heterodyne, frequency standard, and electronic clock each, with a separate module containing two synchronous readout devices, a cross-correlator, a spectrum analyzer, and a computer. Interference signals are sent from the two receivers to the processing module either by conveyance on tapes or disks, or over cable, relay, or satellite communication links depending on how much time is allowed between signal reception and appropriate action based on data analysis. Introduction of an artificial earth satellite into the radio interferometer system facilitates not only establishment of a space communication link but also simulation of a cosmic radio-emission source. Radio interferometry of remote cosmic radio-emission sources is done in nonrotating inertial coordinates. Time scales far removed from one another are synchronized by the method of bilateral radio communication over satellite, which requires very precise time delays in on-board recording systems. Figures 1; references 12: 7 Russian, 5 Western (1 in Russian translation).
[154-2415]

STATISTICAL ANALYSIS OF ATMOSPHERIC CORRECTIONS TO LASER OBSERVATIONS OF
ARTIFICIAL EARTH SATELLITES

KOCHANOV, K. N., MAKSIMTSEV, S. A., POLYAKOVA, Ye. N., CHISTYAKOV, A. D.
and YUNOSHEV, L. S.

[Abstract] A statistical model describing the vertical distribution of
atmosphere parameters has been constructed for calculating the corrections
to laser measurements of the distances to artificial earth satellites. The
distance correction is calculated as a function of pressure on the basis
of layer-by-layer integration between boundaries at which readings are
taken, layers including those with uniform temperature and humidity, as well
as those with uniform altitudinal temperature and humidity gradients, with
a correction also made for the speed of light through a spherically stratified
atmosphere. The model has been programmed in FORTRAN and used for tracking
a satellite over 1-2 h periods in winter, spring, summer, and fall from
locator stations not more than 30 km apart. An evaluation of corrections
and correction differences based on these data has yielded a correlation
coefficient of 0.979 for the pressure dependence of the distance correction,
with the atmospheric pressure at a locator station normalized to the standard
atmospheric pressure. The results indicate that atmospheric pressure at any
given point contains the most reliable information about the mean-integral
density of the air column above that point and, accordingly, that the
pressure correction alone is sufficient for distance mesurements by means
of a laser beam. This correction should accompany tables of astronomic
refraction indexes. References 2: 1 Russian, 1 Western (in Russian
translation).
[154-2415]

METHODS OF SHAPING PICOSECOND PULSES

SAVITSKIY, Ye. Ye.

[Abstract] Picosecond voltage drops can be produced by one-port oscillator
circuits with negative resistance and positive feedback, using tunnel
diodes with S-form or N-form current-voltage characteristics, by switching
devices such as charge-storage diodes or transistors with sharp cutoff, or
by mechanical devices such as mercury-arc relays. The disadvantages of
mechanical devices, namely low repetition rate and difficult synchronization,
are outweighed by their precision and versatility. A fall time of 0.2-0.3 ns
for pulses of 50-100 V amplitude is now feasible with both semiconductor and

mechanical devices. A major application for picosecond and subnanosecond pulses is factory testing and service inspection of oscillographs. Tables 2; references: 2 Russian.
[154-2415]

ANALYSIS OF PICOSECOND PULSES BY MEANS OF STROBOSCOPIC OSCILLOGRAPHS AND DEVICES

RYABININ, Yu. A., KLEMENSOV, V. A., BALAYEV, A. P., SHCHERBAKOV, V. V. and TSAL', V. V.

[Abstract] Picosecond pulses are analyzed by means of stroboscopic oscillographs and converters. A stroboscopic converter reads instantaneous values of the analyzed pulse train in the signal with short strobing pulses which automatically shift as the signal pulses follow one another and thus facilitates tracking of the signal and resynthesizing it in a different time scale. Such a converter consists of a nonlinearly parametric high-speed switching element controlled by a strobe generator and equipped with an analog memory in the input stage, a synchronizing circuit as well as a sweep circuit with program control of time shift and signal sampling mode in the output stage. The theory of these stroboscopic devices is based on a two-stage model of conversion. This model yields the performance character-istics of said devices, their transient or dynamic parameters as well as bandwidth and sensitivity, noise and distortion, speed and accuracy. An outstanding representative of stroboscopic oscillographs now available is the S7-17 two-channel one with minicomputer, to which a microprocessor with read-only memory and direct-access memory can be added for program control. Other such oscillographs are the two-channel S7-16, the wide-band SK7-18, the universal S7-12, S7-13, S1-91/3, S1-91/4 with interchangeable modules, and the computing S9-9 with built-in microprocessor for many functional applications. Figures 3; tables 1; references 13: 8 Russian, 5 Western.
[154-2415]

DEVELOPMENT OF METHODS FOR MEASURING ONE-SHOT SIGNALS ON BASIS OF TIME SCALE
CONVERSION

GOLOVASTIKOV, Yu. A., STEPANOV, B. M. and FILINOV, V. N.

[Abstract] Parameters of one-shot fast processes of nanosecond or pico-
second duration are measured by the method of time scale conversion. Devices
operating on this basis are special-purpose high-speed cathode-ray memory
tubes, no other devices being capable of dealing with a rise time shorter
than 1 ns. The major problem is to ensure sufficiently fast signal record-
ing and thus a sufficiently fast sweep of the tube screen by the electron
beam. Use of a microchannel plate operating in the saturation mode has
been proposed as a solution of the problem, the tube input current necessary
for saturating such a target depending on the characteristics of the latter
as well as on the accelerating voltage. A design and performance analysis
based on electron ballistics yields the requirements. Latest developments
in scanning techniques and in data processing and storage with cathode-
ray tubes make it feasible to meet these requirements. The latest two
instruments developed for this application are the single-channel INI-6
operating with an "Elektronika-60" microcomputer and a CAMAC crate, and the
two-channel "Lotos-P" operating with an "Etalon" minicomputer. Both instru-
ments use a 2TZS cathode-ray tube. Each instrument is subject to additive
and multiplicative noise at the output, the multiplicative noise component
influencing only the ratio of signal to additive noise under which the
maximum recording speed is reached. The conversion errors are: amplitude
error 5% (both instruments), time error 2% (INI-6) and 5% ("Lotos-P").
Tables 1; references 15: 14 Russian, 1 Western.
[154-2415]

MULTICHANNEL OSCILLOGRAPHIC MEASUREMENTS OF PARAMETERS OF PICOSECOND
SIGNALS

AVER'YANOV, K. P., SPERANSKIY, Yu. V., STEPANOV, B. M., CHURAKOV, V. P.
and CHALKIN, S. F.

[Abstract] Development of lasers capable of emitting subnanosecond pulses,
through active or passive intracavity mode locking, has created the need
for means of measuring the parameters of such pulses, their interaction
with matter, and their correlation with the pumping radiation. High-speed
oscillography is most suitable for this purpose. Instruments for this
application must contain facilities for recording fast one-shot processes

and distortionless recording of picosecond signals, must have several
channels available and have all the channels rigidly coordinated in time.
A typical 3-channel oscillograph which meets these requirements includes
three light-splitter plates, three primary instrument transducers, three
oscillographic recording devices, and one common sweep generator or three
separate ones. The cathode-ray tube of this oscillograph or of others
must contain a deflection system with a 5-10 GHz signal passband, a record-
ing speed of at least $300 \cdot 10^3$ km/s for one-shot processes, and a sweep
duration not longer than 1 ns. The oscillographic recording devices can
be connected in parallel or in series. Combining one channel and a
6LOR-04 laser instrument with a "fast" scan and a "slow" scan facilitates
analyzing the fine structure of nanosecond pulse trains, with precise time
coordination. Figures 3; references 7: 6 Russian, 1 Western.
[154-2415]

WIDEBAND OSCILLOGRAPHIC CATHODE-RAY TUBE WITH 50 ps TIME RESOLUTION

AKIMOV, Yu. A., BOBROVICH, G. D., KRUTYAKOV, Yu. A., MORKOVIN, V. G. and
STEPANOV, B. M.

[Abstract] A wideband cathode-ray tube with 50 ps time resolution and a
7 GHz passband has been developed for multichannel oscillographic measure-
ment of one-shot processes and their time correlation. This ITBU-7 tube
contains a cathode, a modulator, a gate, two wideband feedthrough deflect-
ing systems for signal calibration with 1.8 GHz and 3.5 GHz passbands,
respectively, two deflecting plates for permanent beam shifting along the
axes and in time, an asymmetric grooved signal retarding-deflecting system
formed by a meander strip line, a wideband feedthrough intermittent signal
deflecting system with 1.8 GHz passband, and a microchannel plate before
the screen. Focusing and deflections are electrostatic. The signal de-
flecting system has a retardation factor of 7.5, which correspond to an
accelerating voltage of 4.5 kV, a characteristic impedance of 50 ohms, a
sensitivity of 1.5 mm/V, and an amplitude-frequency characteristic flat
within 10% over the 0-6 GHz range and within 30% in the 7-7.5 GHz range.
The phase-frequency characteristic was measured for an electromagnetic
range. The transient characteristics were measured with a Gunn-effect diode
oscillator as a generator of steep voltage drop. Figures 1; references 3:
2 Russian, 1 Western.
[154-2415]

MEASUREMENT OF FREQUENCY CHARACTERISTIC OF MICROWAVE CIRCUITS WITH PICOSECOND PULSES

ANDRIYANOV, A. V., ZAKHTARENKO, V. S. and CHEPURNOV, A. V.

[Abstract] A test stand has been designed and built for measuring all parameters in the scattering matrix with one setting of the test object, specifically a microwave circuit. The instrumentation includes a stroboscopic converter with three inputs: one to the generator of probing signals and two, each to a feedthrough mixer. The microwave channel of this converter also contains three program-controllable switches and two matched loads for operation in two reflectometer modes and one oscillograph mode. Tunnel-diode oscillators serve as sources of the widest-band probing signals. Because of interference signals produced by rereflections, measurement of the reflection coefficients is the worst-case mode of operation. Layout and performance analysis of the instrument components for this critical mode of operation is facilitated by the space-time diagram of signal propagation through the system and the corresponding signal trace appearing on the oscillograph screen. Such an analysis reveals a time "window" which limits the reflectometric capabilities of the test stand pertaining to distributed-parameter circuits, a 2 ns wide window limiting the maximum electrical length of the measurable circuits to 30 cm, so that measurements with an unmatched signal generator must be performed at the highest possible frequencies in the 1-18 GHz range. A simpler variant of this test stand is one where all the S-parameters are measured in two settings of the circuit, one in the forward connection and one in the reverse connection. Figures 2; references 7: 6 Russian, 1 Western.
[154-2415]

AUTOMATED SYSTEMS FOR MEASUREMENTS IN TIME DOMAIN

KRYLOV, V. V., GLUSHKOV, V. D. and KOCHETKOV, A. A.

[Abstract] The first automated systems for measurement of time characteristics with a stroboscopic oscillograph and a generator of picosecond pulses were built so as also to include a minicomputer and an analog-to-digital converter. The latest systems TDANA (US), WAWA (Japan), ASIVO (USSR) and ASPEIVO (USSR) basically contain a generator of picosecond probing pulses, a mixer, a stroboscopic oscillograph, an interface, a minicomputer, and a display. An essential role in setting up any of these systems is synchronization of the code readout from the analog-to-digital converter with the shift

of strobing pulses in the mixer. Highest accuracy and sensitivy are achieved by means of "deep" signal storage and by eliminating the "slow" drift component of noise in the stroboscopic converter. The error of signal input to the computer memory is then determined only by the "fast" jitter noise in the horizontal channel and by nonlinearity of the oscillograph sweep, which can be suppressed by removal of the "fast" sawtooth voltage. The dynamic error is minimized by optimal digital filtration using the algorithm of solution of the reverse problem for a convolution equation. Such automated measuring systems are designed to improve the characteristics of recording instruments and of probing-signal generators, to transform data into the frequency domain, using the algorithm of a fast Fourier transformation, to identify parameters of measured objects, to represent data graphically, to control the operation of instruments, and to facilitate dialog with the user. Figures 2; references 18: 12 Russian, 1 Hungarian, 5 Western.
[154-2415]

MEASUREMENT AND IDENTIFICATION OF PARAMETERS OF WIDEBAND CHANNELS BY MEANS OF PICOSECOND VIDEO PULSES

GLEBOVICH, G. V., KOVALEV, I. P. and PONOMAREV, D. M.

[Abstract] The nonhomogeneity parameters of coaxial and strip lines are calculated either by a simple method from the parameters of a probing signal and the maximum reflected signal amplitude, which is accurate only for small inhomogeneities, or by a more universal method from the area under the reflected signal. The latter method is applicable to various inhomogeneity models such as a capacitance shunting a line segment, an inductance in series with a transmission line, and an array of densely spaced inhomogeneities. Reflectometers with stroboscopic oscillographs and generators of probing pulses with subnanosecond rise time are available for measuring minimum capacitances of 0.008-0.02 pF and inductances of 0.01-0.05 nH. The frequency characteristics of circuits and devices are determined through measurement of the scattering matrix and the transmission matrix, which can be done with the automated systems ASIVO (USSR) and TDANA (US). A method of identifying the parameters of physical inhomogeneity models is proposed which is based on using the coefficients in the linear differential equation constituting the mathematical model of linear objects. This method involves a Laplace transformation which yields a fractional-rational transfer function, selection of model parameters and establishment of a relation between discrete inhomogeneity models with minimum functional error (deviation of the output signal from the experimentally determined response signal of models). This requires a spectral analysis of that response signal and analog-to-digital conversion of computer-aided processing of the instrument output signal. The efficiency of this method has been demonstrated experimentally

on wideband amplifiers, on filters, and on intricate discrete inhomogeneities in a transmission channel. In one experiment the ASIVO automated measuring system was used to identify the model of a wideband amplifier and to determine its frequency characteristics. Figures 1; references 13: 11 Russian, 2 Western (1 in Russian translation).
[154-2415]

ACCURACY OF ANGULAR COORDINATE MEASUREMENTS OF SEVERAL SIGNAL SOURCES EMPLOYING ANTENNA ARRAY

VARYUKHIN, V. A., POKROVSKIY, V. I. and SAKHNO, V. F.

[Abstract] The accuracies with which the angular coordinates of two signal sources are estimated by statistical and deterministic algorithms are compared by computer. The statistical algorithm investigated employs the maximum of the likelihood function, and the deterministic estimates employ equations which contain the characteristics of the directivity of the channels of an array having coefficients comprised of the channel voltages. Two different versions of the deterministic approach are considered: in the first, a number of array channels are formed in which the maxima of the directivity characteristics coincide with the directions of the sources. In the second version, a set of channels having fixed maximum directions which are not connected directly with the directions to the sources is formed, and the angular coordinates are found from a formula presented in the text. The performance of all three algorithms is compared for two signal sources. It is found that the maximum likelihood and deterministic estimates are practically the same, but that the maximum likelihood algorithm requires an order of magnitude more machine time than the first deterministic algorithm, and two orders of magnitude more than the second. Tables 4; references 5: 4 Russian, 1 Western.
[213-6900]

CASCADE BALANCING DEVICES

SEMENOV, A. V. and KULINICH, A. P.

[Abstract] The attenuating characteristics of phased and antiphase waves
in cascade balancing devices are analyzed on the basis of the theory of
coupled lines, assuming that the waves in the lines are close to T waves.
Line losses are disregarded. It is found that phased waves can be suppressed
to any desired degree by increasing the number of stages in the balancing
device. The attainable degree of suppression is limited by the periodic
conductances which unavoidably occur in the manufacturing process.
Figures 1; references 9: 6 Russian, 3 Western.
[192-6900]

APPROXIMATE METHOD FOR CALCULATING STEP IRREGULARITIES IN RECTANGULAR AND
COMB DIELECTRIC WAVEGUIDES

ANDRUSHKO, L. M., YESHCHENKO, P. S., LEVCHENKO, Ye. G. and MARKOV, S. Ye.

[Abstract] Step irregularities in rectangular and comb dielectric waveguides
which consist of a dielectric plate and a strip on a metal substrate are
investigated. The effective dielectric permeability method is employed, which
allows a rectangular or comb dielectric waveguide to be viewed as a two-
dimensional structure. The method makes it possible to estimate losses
caused by the reflection and radiation of energy occurring because of a
discontinuity in the height or width of a dielectric rod or directing comb
in a rectangular or comb dielectric waveguide. Figures 4; references 11:
3 Russian, 8 Western (2 in Russian translation).
[192-6900]

DESIGN OF PLANAR PATTERN FORMATION CIRCUITS

BLOKHINA, N. A. and MISHUSTIN, B. A.

[Abstract] The synthesis of planar pattern formation matrices designed
for forming amplitude-phase distributions on N radiators of an antenna
array to provide N orthogonal radiation patterns is examined. Possibilities
of creating planar pattern formation circuits which are more compact than
the Blass matrix are discussed. The topology of a planar circuit for an
8-element antenna array is presented as an example. The planar circuits
examined can also be implemented with rectangular waveguides with their
narrow walls connected. Directional couplers are implemented as slot
bridges, and waveguide dielectric inserts are used to create the phase
shifts. Figures 3; references 2: 1 Russian, 1 Western.
[192-6900]

SYNTHESIS OF VARIABLE WIDEBAND PHASE INVERTERS EMPLOYING SECTIONED
MULTILAYER PLANAR WAVEGUIDES

VOROB'YEV, P. A. and REPKO, V. N.

[Abstract] The synthesis of phase inverters based on coupled line sections
with a multilayered dielectric is discussed. A mathematical model of a 29-
section coupled stripline is implemented as a program for computing frequency
responses on an M220 computer. The amplitude-frequency and phase-frequency
characteristics of sections filled with heterogeneous dielectric material are
found to be close to those characteristics of homogeneous transmission lines.
A 4-bit phase inverter incorporating 29 sections with losses not exceeding
2 Db and phase-frequency characteristic deviation from linear not exceeding
5 degrees is designed on the basis of the machine synthesis method proposed.
Figures 2; references 10: 8 Russian, 2 Western in Russian translation.
[192-6900]

WIDEBAND MICROWAVE DEVICE BASED ON LOG-PERIODIC STRUCTURE

YATSKEVICH, V. A.

[Abstract] A wideband microwave device is described which incorporates the
principle of logarithmic periodicity as well as the cutoff principle. The
device consists of geometrically similar components with dimensions increas-
ing in a geometric progression with distance from the plane of the input
and output terminals toward the loads. The device is analyzed by means of
ordinary methods from the theory of microwave circuits, assuming that the
line segments and capacitances comprising the device are ideal. The device
can be employed as a bandpass filter or as a wide band impedance transformer.
The use of the device as a phase-shifting circuit is analyzed. The proposed
device is advantageous over previous microwave devices in that it incorporates
no coupled lines, which are difficult to design. Figures 2; references 5:
4 Russian, 1 Western.
[192-6900]

RADIATION OF OPEN END OF MICROSTRIP LINE

SHABUNIN, S. N.

[Abstract] An electrodynamically valid method for designing heterogeneities
in the form of an idler microstrip line is proposed. The analytical find-
ings are compared with experimental results, indicating that the proposed
method is sufficiently accurate. The relative simplicity of the expressions
derived allow the findings obtained to be employed in computer-aided systems
for designing microwave integrated circuits. The proposed method can also
be used for analyzing certain types of microstrip antennas and antenna arrays.
Figures 2; references 6: 3 Russian, 3 Western.
[192-6900]

EPITAXIAL FILMS IN MICROELECTRONICS

BAGDASAROV, Kh. S., doctor of physical-mathematical sciences,
KOBZAREVA, S. A., candidate of chemical sciences and RAMBIDI, N. G.,
doctor of chemical sciences

[Abstract] A general description of the use of epitaxial films in micro-
electronics is presented. The manner in which epitaxial films are formed,
and the general properties of such films, are described. Factors influenc-
ing the growth of epitaxial layers are outlined, and methods for identifying
defects and controlling the epitaxy process are detailed in brief. Basic
methods by which epitaxial films are grown are explained. References:
3 Russian.
[278-6900]

ECONOMICAL TESTER FOR CMOS-MICROCIRCUITS

SAFRONOV, V. I., senior electromechanic, first control track section, Dnepr
Railroad line, and TROTSENKO, V. I., chief of track section

[Abstract] A logic tester for CMOS microcircuits such as series K145 and
K175 in telephone sets is proposed in lieu of the oscillograph now used for
fault location during repair. The only data required for fault location and
repair are signals at two logic levels at certain points in a circuit. The
tester is multifunctional, simple in construction and economical in operation.
Its input stage consists of two threshold detectors in parallel, one for
logic "1" and one for logic "0". Their outputs are connected directly to
indicators of logic "1" and logic "0" respectively. They are also connected
through a common RS trigger and a bipolar pulse rise detector to a transient-
state analyzer. The latter has one output to a pulse indicator and another
output to a pulse series and sequence indicator. All four indicators are
segments of a liquid crystal. Other components are built with series K561
microcircuits, the RS trigger using NOR gates and the pulse rise detector
using EXCLUSIVE-OR gates. A generator consisting of two inverters and
operating by the twist effect produces a 200 Hz meander voltage for the liquid
crystal. Such a tester, assembled on a printed-circuit board, is already
used in service. Figures 2.
[155-2415]

MICROWAVE POWER DIVIDER WITH FILTERING PROPERTIES

BELOV, A. S., UKRAINTSEV, Yu. S. and ZHIROV, V. V.

[Abstract] A microwave power divider is described which combines the
properties of a directional coupler and a frequency filter. The basic model
is a passive linear 4-port consisting of lumped reactances coupled by con-
ductance inverters. An algorithm for synthesizing the filter-divider is
presented. The analytical results are confirmed by tests performed on an
experimental prototype. The output sections are theoretically ideally
decoupled at all frequencies. The filter-power divider can be employed in
bridge devices in which filters are combined with directional couplers,
thus significantly reducing the size and weight. References: 4 (2 Western).
[212-6900]

EXPERIMENTAL INVESTIGATIONS OF MASER POST DELAY STRUCTURE ARRANGED
ASYMMETRICALLY WITHIN SHIELD

SHAMFAROV, Ya. L. and STETSENKO, A. I.

[Abstract] The possibility is investigated of improving traveling-wave
maser stability by increasing the coefficient of nonmutuality of the ferrite
element by shifting the plane of the comb from the geometric center of the
shield. The comb delay structure of a traveling-wave maser with the active
ruby crystal on the side of the plane of the comb closest to the side wall
of the shield, and a thin dielectric plate and the ferrite nonmutual element
on the other side is considered. It is shown that shifting the plane of the
comb from the geometric center of the shield closer to the electrical center
doubles the coefficient of nonmutality of the ferrite element and increases
the stability and gain of the laser. It is asserted that a symmetrical
delay structure placement can also be employed in traveling wave masers
operating in other bands, including the millimeter band. Figures 3;
references 5: 4 Russian, 1 Western in Russian translation.
[236-6900]

98

DEVICE FOR IDENTIFYING FAULTY MICROCIRCUITS

TSYGANOV, NIKOLAY IVANOVICH, chief engineer, Bauska Communications Center,
Latvian S.S.R.

[Abstract] A simple device is described which is used for identifying faulty
K155 and K133 series microcircuits in individual modules or on boards, with-
out removing them from the circuits, or for testing ICs before installation.
The device incorporates a frequency division module, a logical level output
module, an amplifier for an acoustic variable signal indicator, and a leader
to indicate fixed logic levels. Schematic diagrams of the device are pre-
sented, and the operation of each section is described. Properly assembled,
the device requires no adjustment. Figures 3.
[215-6900]

PULSE GENERATION OF MICROWAVE OSCILLATION IN RELATIVISTIC BACKWARD-WAVE
TRAVELING-WAVE TUBE DEVICE

AFONIN, A. M. and KANAVETS, V. I.

[Abstract] The nonlinear theory of unsteady generation and amplification
is extended to devices employing longitudinal interaction of a strong-
current relativistic pulsed flux with the poles of a corrugated or diaphragm-
type waveguide delay system. The interaction with the direct and return
waves which is characteristic for traveling- and backward-wave tubes is
taken into account, as well as the effects of the variable longitudinal
field structure, the pulsed variation in the parameters of the electron
beam and the high electron load. The device in question operates at a π-
type frequency at the boundary of the band. The method derived is employed
to investigate processes occurring in a cold system. The use of the
equivalent circuit method for analyzing such systems is validated. It is
shown possible to obtain spike generation and electron frequency tuning.
The possibility of generating power nanosecond microwave pulses is
demonstrated. Figures 5; references: 13 Russian.
[213-6900]

THREE DIMENSIONAL SOLUTION OF PROBLEM OF POTENTIAL OF ELECTRON BUNCHES IN
HYBRID FIELDS

BAYBURIN, V. B.

[Abstract] Analytical solutions are obtained for the potential of electron
bunches of arbitrary configuration in the three dimensional Poisson inter-
action space of M-type devices. Solutions are obtained for the three-
dimension Poisson equation, with allowance made for the conducting planes
in the interaction space and the potential periodicity condition. It is
shown that two dimensional solutions are close to three-dimensional for most
of the anode height, thus validating the two-dimensional approximation for
calculating Coulomb fields. The ternary Fourier series method can also be
employed for other boundary conditions, e.g. when the periodicity condition
is replaced with the condition that the potential in sections X=const be zero.
Figures 5; references: 12 Russian.
[213-6900]

TRANSFORMATION OF COMPLEX AMPLITUDE-PHASE FIELD DISTRIBUTION TO GAUSSIAN
BY SINGLE-MODE WAVEGUIDE

BONDAREV, L. A., BUDAGYAN, I. F., DUBROVIN, V. F., GRIGOR'YANTS, V. V.,
MIROVITSKIY, D. I. and SMYK, A. F.

[Abstract] The use of single-mode optical waveguides with different profiles
of the index of refraction to obtain Gaussian-type field distributions is
examined. A device for investigating the excitation of optical waveguides
and measuring the characteristics of the perturbing fields is described. It
is found that the power transferred by the primary mode can be increased up
to five-fold when a single mode waveguide is excited by a field with a complex
amplitude-phase distribution. The theoretical estimates agree well with
the experimental findings. The results can be used in microwave optics and
for converting the radiation from multimode lasers. Figures 2; tables 1;
references 5: 4 Russian, 1 Western.
[213-6900]

POSSIBILITY FOR EXTRACTING SURFACE WAVE ENERGY FROM PLASMA WAVEGUIDE

ZAGINAYLOV, G. I., KONDRATENKO, A. N. and KUKLIN, V. M.

[Abstract] The possibility of converting surface wave energy to radiant
energy as the result of diffraction on an abrupt jump in plasma density is
examined. The amplitude coefficient of reflection and transmission of the
surface wave from a density discontinuity are calculated; the coefficient
reflection is found to depend upon the frequency of the wave and the density
discontinuity, while the transmission coefficient is determined only by the
ratio of the plasma densities. Analysis indicates that practically all of
the surface wave energy is transformed to radiation, and that the directivity
pattern is maximum when phi = pi. The size of the discontinuity must be
much smaller than the length of the surface wave in order for the findings
to be valid. Figures 1; references: 6 Russian.
[213-6900]

POWER ENGINEERING

MUTUAL IMPEDANCE OF VIBRATORS IN CONDUCTING MEDIUM

[Annotation of article deposited at Central Scientific Technical Institute
'Informsvyaz'', No 268]

KORCHAGIN, Yu. A. and VERKHOVTSEVA, Ye. Ye.

[Abstract] Analytical expressions are derived for input impedance and mutual
impedance of vibrator pairs in a boundless isotropic conducting medium with
dielectric permittivity $\varepsilon_c = \varepsilon - 160\lambda\sigma$ and magnetic permeability $\mu = 1$ (λ-
wavelength, σ- electrical conductivity). One pair of vibrators is a parallel
one, with arbitrary currents at their ends. Another pair of vibrators is a
collinear one, with zero currents at their ends. The current distribution
along each vibrator depends on the complex propagation constant, on the
vibrator length, on the input current, and on the phase shift. The mutual
impedance depends also on the distance between vibrators and on the wave
number in the medium. The obtained relations are applicable to single
vibrators and to arrays of vibrators. Figures 2; references: 1 Russian.
[165-2415]

IMPROVEMENT OF OVERVOLTAGE PROTECTION FOR TELEMECHANICAL AND AUTOMATION
EQUIPMENT

FILIPPOV, B. N., chief, Signalization and Communication service, and
BELYAYEV, N. M., senior engineer, Automation, Telemechanics and Communication
laboratory, Oktyabr Railroad line, and LISOVSKIY, M. P., assistant professor
(dotsent), Leningrad Institute of Railroad Transportation Engineers

[Abstract] During the stormy season, 40-150 failures of railroad tele-
mechanical and automation equipment occur along the Oktyabr line. Since

1977 the management of this railroad line and the Leningrad Institute of
Railroad Transportation Engineers have conducted joint scientific and
practical studies on improvement of the overvoltage protection. Semi-
conductor devices are most vulnerable (70% of all failures), but ASSh2-220,
TSh-2000V, and IMVSh-110 electromechanical relays also fail. Thermal
breakdown of p-n junctions during avalanche breakdown, during recovery of
reverse resistance, or during forward current inrush is the basic cause of
failure. An evaluation of these processes in most widely used silicon
diodes and a performance analysis of many protective circuits using such
devices have led to development of new means of overvoltage protection.
These means include overvoltage limiting and energy absorbing devices,
specifically ZnO varistors with fuses for their protection. Where a single
varistor is inadequate, several varistors are staged with LC-filters
separating them not only for proper energy distribution but also for limiting
the rate of voltage rise dV/dt. Special devices such as dischargers must
be used instead of varistors where thunderstorms are heavy and frequent. An
elaborate scheme covering the entire railroad line includes BPSh and PPSh
power supplies as well as ASSh2 relays for monitoring the state of the
protective equipment. Internal connections are minimized and where possible
replaced with accessible external ones. Figures 6.
[155-2415]

NATIONAL ECONOMIC EXPENDITURES FOR ENERGY

MELENT'YEV, L. A. and VARTAZAROVA, L. S., Moscow

[Abstract] An analysis is given of structural variations in energy expendi-
ture for 1961-80 with a breakdown of component inputs which make it possible
to determine suitable proportions for the development of the energy sector
with respect to capital and labor input and energy reserves and to improve
energy forecasting and select optimal directions for future investment. The
historical review shows that the energy sector is one of the principal capi-
tal and labor consuming areas of the economy and absorbs up to 30% of the
basic industrial capital of the country and approximately 13% of the industrial
labor force. In 1960-80, energy sector work efficiency and electrification
increased which lead to a rise in the energy effective use coefficient.
The aggregate economic output for the entire economy including energy rose
in a relatively smooth curve. Negative features in energy were the increased
fuel production and transport costs and the use of expensive mechanical
energy in the economy. Energy efficiency should be raised, labor productivity
and automatization upgraded, depleted energy sources abandoned and coal use
increased. Figures 1; tables 8; references: 10 Russian.
[223-12497]

ON SOME RESULTS OF WORK CONCERNING SYSTEMIC RELIABILITY IN ENERGY SECTOR

RUDENKO, Yu. N., Irkutsk

[Abstract] Since 1973 a seminar on "Methodological problems in research on
the reliability of large-scale energy systems" has met in order to consider
network problems of electrical energy, heat, gas and oil distribution systems
but not coal or nuclear energy networks. The present paper introduces a
series of the seminar's reports appearing in the same journal issue. Basic
attention was given to intersectoral reliability problems taking into account
the interaction of primary energy sources in energy conversion such as
electricity and heat generation and interaction conditions. Specific
computerized network design and management subjects were considered such as
reliability indicators, standards, mathematical models and reserves.
Theoretical management studies are reviewed including a single standardized
data base developed by the Ministry of Energy and other energy system design
and management methodology and standards.
[223-12497]

STATE OF DEVELOPMENT OF ENERGY SYSTEM RELIABILITY COMPUTATION METHODS AND
WAYS TO IMPROVE THEM

ROZANOV, M. N., Irkutsk

[Abstract] An analysis is presented of the reliability of large-scale
energy systems (electricity, gas, oil, heat and water) by means of
methodology based upon common systemic features illustrated by a flow
pattern of linked resource, generation, storage, transport and user
elements. In order to determine reliability, the system is broken down
into three components which are found to determine production: 1) primary
resource, 2) power or output comprising generation, transport and storage
elements and 3) distribution. Existing methods are surveyed for computing
reliability and it is found that the second and third components are
sufficient for the evaluation, with adequate results for practical applica-
tions. There are no adequate methods for taking into account the first
component and further work is necessary in order to improve formulation of
the second except for electrical systems. Because reliability computations
are based upon a common structural concept, results and methods can be
compared. Figures 1; tables 1; references: 20 Russian.
[223-12497]

DEVELOPMENT OF METHODS FOR ANALYZING RELIABILITY OF MAIN CIRCUITS OF ELECTRIC
POWER STATION CONNECTIONS

GUK, Yu. B., Leningrad

[Abstract] Developments in recent years with respect to the analysis of
electric network reliability are surveyed. The increasing size of networks
caused by the introduction of atomic power stations made the design and
analysis problem more pressing. Reliability indicators were developed in
the form of failure frequencies and mathematical expectations for consumption
or generation drops and systemic factors affecting reliability were identified.
Analytic methods were introduced and programmed for computerized treatment
and design, but various analysis methods including logical set descriptions
with conjunctions showing failure and matrix topological methods are used.
Problems were encountered as to the reliability of the initial data which
hampered the attainment of sufficient determination and it was found that
measurements of logical conjunctions could be used for reliability evaluation.
Computer programs are being applied for circuit selection, operational
analysis and equipment evaluation. References: 15 Russian.
[223-12497

METHOD OF DESIGNING PROTECTIVE SYSTEM FOR COMMUNICATION LINES AGAINST
HAZARDS FROM POWER TRANSMISSION LINES

KOSTENKO, M. V., Leningrad Polytechnic Institute

[Abstract] In order to protect communication lines against excessive electro-
motive force induced from neighboring overhead superhigh-voltage power trans-
mission lines, it is necessary to install dischargers with grounding devices
on the lines. A precise engineering method of selecting the optimum number
and locations of such dischargers is proposed, with utilization of the shielding
effect produced by opposing asymmetric short-circuit currents in the power
line at the fault site. The object is to ensure that nowhere along the
communication line will the voltage to ground exceed its maximum permissible
level under the worst conditions. Calculations are based on a physical model
of the shielding effect and on an equivalent circuit which includes current
return paths through the ground. Standard theoretical and semiempirical
relations for impedances, emfs and currents are used for calculating the

voltage profile along a line segment with a fault site between two dis-
charger locations. Curves of the shielding factor and the corrective
proximity factor are plotted, both as functions of the normalized distance
from the fault site. These curves and an approximation based on the "end
points" method within a +5% accuracy facilitate calculations pertaining
to the discharger array and the necessary grounding impedance. These
calculations are targeted for design optimization, namely minimizing the
number of dischargers and the cost of grounding devices. The method is
demonstrated by a typical simple example of parallel proximity for a four-
wire communication line consisting of copper conductors on wooden poles.
Figures 6; references 8: 7 Russian, 1 Western.
[242-2415]

POWER FIELD-EFFECT TRANSISTORS IN POWER APPARATUS (REVIEW)

D'YAKONOV, V. P., doctor of technical sciences, Moscow Order of Lenin
Institute of Power Engineering, Smolensk branch

[Abstract] Applications and performance characteristics of power MOSFETs are
reviewed, the usefulness of these devices deriving from three basic design
concepts: 1) large-scale paralleling of identical elementary structures on
a common substrate; 2) high-resistance drain region (proposed by V. V. Bachurin
and O. V. Sopov); 3) "vertical" configuration with down flow of electrons
from source array at top of chip to drain adjoining the substrate. Two
Soviet-made devices, KP904 with horizontal structure and KP909 with V-structure,
are matched against the Americal "Siliconix" VN-64 GA and the Japanese 2SK-134
with V-structures, the American "International Rectifier" IRF 150/350 with
hexagonal structure, and the West German "Siemens" BUZ-15/34/54/84 with
SIPMOS structure. Applications for power MOS field-effect transistors
generally include single-sided and push-pull inverters, motor speed regulators,
secondary power supplies with relay-characteristic stabilizers, secondary
power supplies without low-frequency transformers, commutators of analog
signals, transmission line voltage regulators, stabilizers, compensators,
also apparatus for microwave and ultrasonic treatment. Although all semi-
conductor devices feature higher reliability and longer life than electro-
mechanical-electromagnetic ones, with lower control power requirement and
absence of contact jitter, the advantage of MOS transistors over bipolar
ones is higher switching speed and power rating. Connection of MOS field-
effect transistors in series is still problematic, because each gate is at
a different potential, but it is often expedient to combine MOS and bipolar
transistors in a common monolithic chip, or to add Schottky-barrier power
diodes. Figures 9; tables 1; references 27: 16 Russian, 11 Western.
[242-2415]

OVERVOLTAGES IN CAPACITIVE ENERGY STORING DEVICES WITH DISCHARGE AT THE LOAD END

YEFIMOV, B. V. and RTISHCHEV, V. M.

[Abstract] Transient processes in pulse-current generators are analyzed, for the purpose of evaluating the overvoltage and overvoltage protection, in a configuration with the protective discharger at the load end. Calculations are based on an ideal equivalent circuit which consists of a voltage source replacing the charged capacitor and a tank circuit with an infinitely large series inductance, connected through a cable with negligible resistance. The analytical solution to the transient voltage problem is supplemented by numerical data in order to indicate the effect of the cable and of the finite discharger speed. These calculations are based on the wave method, with the inductance and the nonlinear capacitance of the discharger transferred from the source side to the load side. According to the results, the amplitude of the load voltage depends only on the nonlinear resistance of the discharger. Figures 3; references: 5 Russian.
[242-2415]

METHOD OF CALCULATING CURRENTS IN LADDER NETWORK WITH FAULTY ELEMENTS.

BOGUSLAVSKIY, I. Z., Leningrad

[Abstract] A Π-ladder network containing emf sources in the series branches is considered, with the assumption that all series impedances and all shunt impedances are respectively identical. The emfs can differ in phase and in amplitude, some being zero in a special case, and the normal currents in all series and shunt branches including source and load are known. The problem is to calculate the currents in such a network containing faulty elements. Current increments are defined first and identified as the criteria of a permissible length of operating time. On this basis, the current distribution is calculated for the appripriate boundary conditions in accordance with Kirchoff's circuit laws. The procedure is to calculate the current distribution without (before) fault and with (after) fault, whereupon the power losses can also be evaluated. A typical example of a ladder network with possibly faulty elements is a salient-pole machine with a damper winding in which one or several elements differ from the rest because of manufacturing imprecision of anomalous local operating conditions. A numerical example illustrates the simplicity and the versatility of this method. References 5: 4 Russian, 1 Western (in Russian translation).
[242-2415]

ANISOTROPY OF PROPERTIES OF COLD-ROLLED ELECTRICAL-GRADE STEEL OF 1 mm GAUGE

YERSHOVA, L. P., engineer, MINTS, B. B., candidate of technical sciences, and KOLOV, M. I., candidate of technical sciences

[Abstract] Nitrided electrical-grade steel 3411 (2.98-3.15% Si, 0.006-0.014% $Al_{dissolved}$) was cold rolled to a gauge thickness of 1 mm and then tested for anisotropy of properties. Specimens cut at 8 different angles to the direction of folling (0, 15, 30, 45, 55, 60, 75, 90°) were annealed under matching conditions. The magnetic induction was measured at 16 levels of magnetic field intensity ranging from 0.2 to 2500 A/m and the specific core loss was then measured at 5 levels of magnetic induction ranging from 0.50 to 1.50 T. With the use of standard magnetization curves according to GOST 12119-80 and a standard formula for estimating the difference between longitudinal and transverse properties, the test data were processed for four separate lots of samples. Mechanical properties were also measured in order to indicate the effect of annealing on stress relief after cutting. The results clearly establish an angle dependence of magnetic properties and qualify 3411 electrical-grade steel of 1 mm gauge as a reference standard for design of large d.c. machines. Figures 2; tables 4; references: 3 Russian.
[242-2415]

EFFECT OF ENERGY DISSIPATION ON AMPLITUDE-FREQUENCY CHARACTERISTIC OF ADMITTANCE OF THIN PIEZOCERAMIC DISK

KARLASH, V. L., candidate of physico-mathematical sciences, Institute of Mechanics, UkSSR Academy of Sciences

[Abstract] A thin piezoceramic disk is considered with polarization normal to the solid-metal electrodes on both of its base surfaces. The mechanical admittance of such a disk, specifically in the mode of radial vibrations, is calculated as a linearly frequency-dependent capacitive susceptance with a corrective conductance term representing mechanical as well as dielectric and piezoelectric losses. An approximate analytical relation is obtained by series expansion of Bessel functions with respect to the small parameter $\kappa_0 s_{11M}$ (κ [kappa]$_0$- dimensionless characteristic frequency, s_{11M}- elastic

compliance), sufficiently accurate for radial vibration modes up to the fourth
order. Measurements at resonance and antiresonance, together with data on
the TsTS-19 piezoceramic material with a Poisson ratio $\nu = 0.37$, indicate
that mechanical losses tend to lower the maximum admittance. These losses
combined with dielectric and piezoelectric ones tend to raise the minimum
admittance. Figures 2; references 8: 4 Russian, 4 Western.
[242-2415]

THEORETICAL AND ELECTROPHYSICAL PROBLEMS OF LIGHTNING AND LIGHTNING
PROTECTION

BOGATENKOV, I. M., candidate of technical sciences, and KHALILOV, F. Kh.,
candidate of technical sciences

[Abstract] Section IV (Theoretical Problems of High-Voltage Electrophysics)
of the Science Council to the USSR Academy of Sciences held an extended
session 18-20 October 1983 in Baku on "scientific principles of electro-
physics and electrical power engineering". Participants included over 50
representatives of 12 institutions from 8 cities. Reports on lightning and
lightning protection were presented by the Azerbaijan Scientific Research
Institute of Power Engineering, the Moscow Institute of Power Engineering,
the Institute of Power Engineering imeni G. M. Krzhizhanovskiy, and the
Leningrad Polytechnic Institute. The topics discussed were: 1) Intensity
of thunderstorm activity and lightning characteristics including space-time
distribution of current waves and the potential profile as well as power
drain; 2) Lightning overvoltages and protection of electrical power equip-
ment, using arresters and ferroresonance suppressors; 3) Lightning protection
of aircraft and other objects constituting inhomogeneities in the atmosphere,
especially near large airports; and 4) Design of special-purpose lightning
arresters for an object emitting hot gases. The conference concluded with
several resolutions pertaining to continuation of lightning research activity,
development of lightning protection for gas-filled cables, a theoretical
study program on utilization of nonconventional concepts such as micro-
electronics and low-voltage circuitry for lightning protection, and the
expansion of experimental research activity. It was also resolved to
inform the USSR Academy of Sciences as well as the USSR Ministries of
Energy and Electrical Equipment Industry about the problems at hand and the
requirements for their solution.
[242-2415]

DYNAMICS OF RADIATION OF TRANSVERSE MODES IN ACTIVE FIELD RESONATOR
CONSIDERING INTERACTION OF FIELD AND MEDIUM

LOGGINOV, A. S. and YUL'BERDIN, Yu. F.

[Abstract] A method is described for solving the dynamic self-conjugate
problem of describing transverse mode generation in a semiconductor layer
with allowance for the mutual influence of the field and inversion. The
formation of the transverse mode spectrum during the lasing process is
analyzed on the basis of the proposed model, and a number of experimentally
observed phenomena are explained. A new self-modulation mechanism is pro-
posed which is based on the occurrence of nonlinear losses during change
in the mode profiles caused by variations in the inversion profile.
Figures 1; references 5: 2 Russian, 3 Western (1 in Russian translation).
[192-6900]

COHERENCE OF OPTICAL-FIBER STIMULATED RAMAN SCATTERING LIGHT CONVERTERS

BUTUSOV, M. M., VAVILOVA, O. S. and MALYUGIN, V. I.

[Abstract] An experimental stimulated Raman scattering optical fiber light
converter system is described. The temporal coherence of the device for
different pumping power levels is assessed. Two mode groups propagated in
the fiber employed, and there was no transfer of energy to the basic HE
mode for concentration of energy near the axis. It is found that the width
of the radiation line of the source and the length of the optical fiber must
be taken into account, because they impose limitations on the spatial co-
herence of the transducer, which reduces the contrast of the output radiation
in multimode optical fibers. Figures 1; references 8: 4 Russian, 1 Western.
[236-6900]

SOLID STATE CIRCUITS

QUALITY CONTROL OF INTEGRATED CIRCUITS BY PARAMETRIC IDENTIFICATION METHODS

POKROVSKIY, F. N.

[Abstract] An approach to quality assessment is described which incorporates
the advantages of two separate methods: checking for the execution of
assigned functions by criterial characteristics, and physical methods. The
proposed approach is based on the fact that changes in the properties of
integrated circuit materials are reflected more strongly in variations of
the parameters of equivalent elements than in the values of external
characteristics. The conditions under which a parametric identification
problem has a unique solution are established. The procedure can be employed
directly for circuits containing only passive elements. Circuits which in-
corporate dependent sources are analyzed by finding the absolute values of
the parameters first, and then establishing their sign in accordance with a
substitution circuit. The use of the method for quality control of a series
249 integrated circuit and a 36-item sample of 249LPIB integrated circuits.
The accuracy of the parametric identification indicates that a unique
solution is achieved, and the quality control procedure can be implemented.
References 6: 5 Russian, 1 Western in Russian translation.
[236-6900]

EXPERIMENTAL INVESTIGATION OF ELECTROOPTICAL SYSTEM WITH PLASMA ANODE

ZAV'YALOV, M. A., NEGANOVA, L. A., TEZIKOV, P. F. and TSKHAY, V. N.

[Abstracg] The findings from an experimental investigation of an electro-
optical system with a thermoemission cathode and anode plasma generated by
an annular gas-discharge source are presented. The experiments were con-
ducted in order to modernize a gun by introducing a plasma anode in order
to increase the perveance. The electron beam current in the system is shown
to be increased significantly by using the plasma anode, and the possibility
of plasma focusing - shaping the beam - by controlling the parameters of the
gas discharge source of the anode plasma is demonstrated. Figures 7;
tables 1; references 16: 12 Russian, 4 Western.
[213-6900]

TRANSPORTATION

INDICATING POSITION OF LOCOMOTIVE ALONG RAILROAD TRACK

AVER'YANOV, L. G., candidate of technical sciences, senior scientific associate, and MAZAYEVA, M. P., engineer, Ural Department, All-Union Order of Labor Red Banner Scientific Research Institute of Railroad Transportation (VNIIZhT); ATAMANENKO, Ye. G., candidate of technical sciences, senior scientific associate, VNIIZhT; SMIRNOV, K. A., group leader, State Planning and Surveying Institute for the Planning of Signalization, Centralization, Communications and Radio in Railroad Transportation (Giprotranssignalsvyaz') and MAZAYEV, engineer, Ural Department, VNIIZhT.

[Abstract] Schemes are developed for indicating, on the dispatcher's display panel, the positions of locomotives along tracks in railroad junctions and switch yards as means of controlling the rolling stock. They are schemes of appropriate interconnections and interlocks, through switches and relays, between track segments and between their counterparts on the dispatcher's light panel. They are designed for locating train locomotives and reserve locomotives, along track segments with semaphors and track segments without any. The basic sequence of events in the locating and indicating process is demonstrated by the simple case of a single track with one shunt and one branch-off to a depot. These schemes are subject to refinement for specific situations and for adaptation to specific switching technologies. Figures 5. [155-2415]

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